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TRIASSIC SPORES AND POLLEN GRAINS  
FROM THE CLEMATIS SANDSTONE

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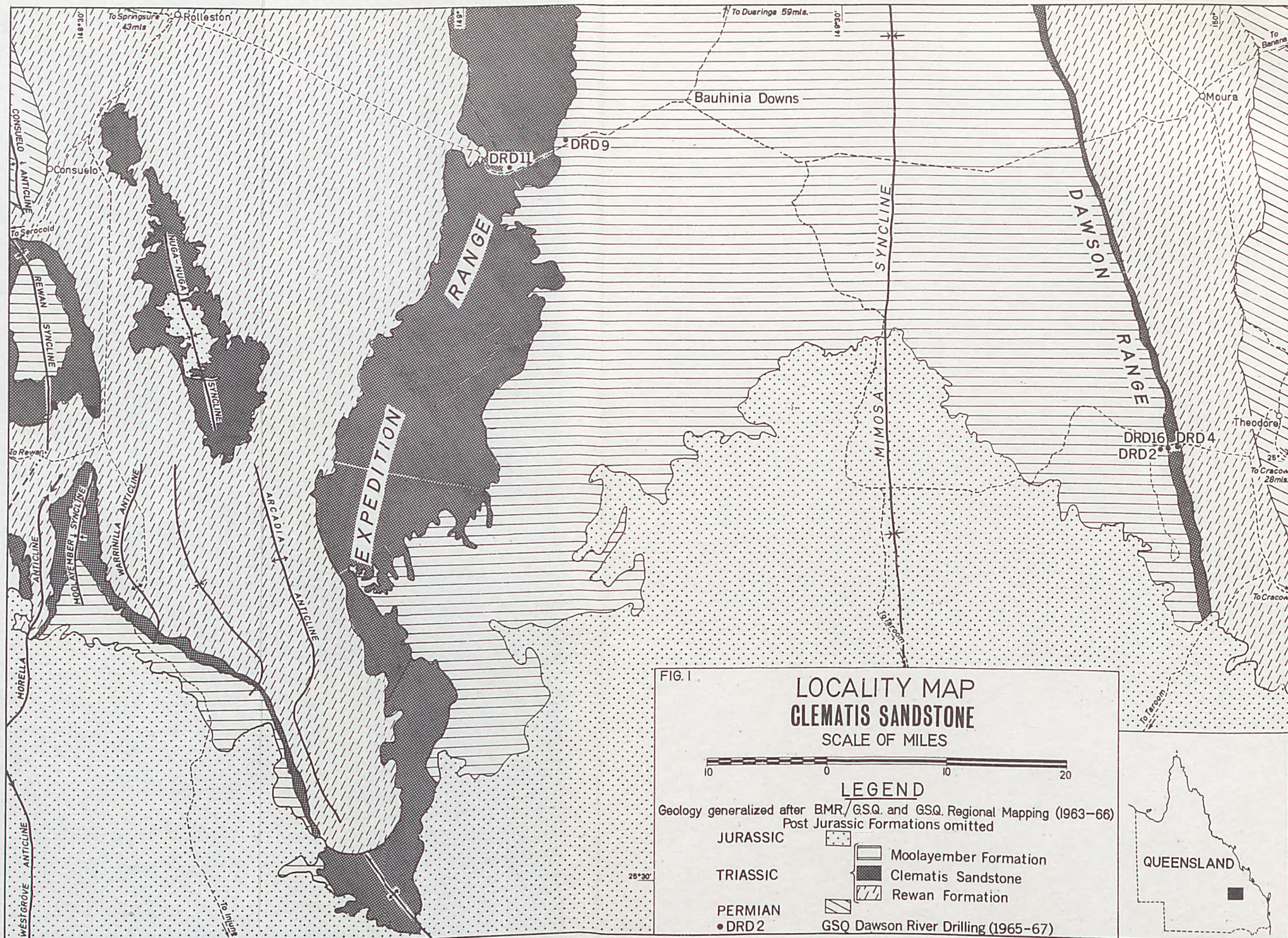














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## ABSTRACT

Microfloral assemblages are described from the Clematis Sandstone, an extensive Triassic formation in the Bowen Basin of Queensland. The assemblages came from twenty-six samples of thin shale beds within the formation in the Mimosa Syncline, where it attains its maximum thickness of about 1,000 feet.

Fifty-three species of spores and pollen grains are recorded. These include three new species, assigned to the genera *Apiculatisporis*, *Guttatisporites* and *Indospora*. The remaining species are identified or compared with species previously described from Australia, Europe, Russia, Canada, India and Argentina, or not formally designated. Three new combinations are proposed for taxa previously described. The generic diagnosis of *Indospora* Bharadwaj, 1962 is emended.

From the stratigraphic aspect, the discovery of species of *Triadispora* and *Voltziaceasporites* in the Triassic of Australia is considered significant. Evidence bearing on the age of the Clematis Sandstone, based on the distribution of these and other European species, is discussed; the Clematis assemblages are regarded as late Lower Triassic or early Middle Triassic.

The microfloral sequence of genera and species in the Mimosa Syncline is illustrated by two distribution diagrams. Species which are of stratigraphic significance within this sequence are indicated and the Clematis assemblages are compared with those from the overlying Moolayember Formation. The investigation will provide a basis for correlation studies in sediments of similar age elsewhere in the Bowen Basin.

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## INTRODUCTION

The Clematis Sandstone is the middle unit of three Triassic formations in the Bowen Basin, in Queensland. It is conformably overlain by the Moolayember Formation; the relationship to the underlying Rewan Formation is an unconformable one in some areas (Phillips, 1960, p. 280) and gradational in others

(Gray, 1968, p. 6). The Clematis Sandstone is distinguished from both these formations by its coarser lithology, as it consists dominantly of medium- to coarse-grained sandstone, with very minor proportions of shale and siltstone, in contrast to the greater proportions of these finer sediments in the other two units. Regarding its deposition Malone has stated (1964, p. 278) "The uniform blanket of the Clematis Sandstone possibly accumulated in a fluvial environment, during a period of slow, widespread subsidence which followed the rapid, localized downwarping of Rewan Formation time".

The Clematis sediments contain plant macro-fossils, as well as the spores and pollen grains, which form the subject of this paper. The macro-floras recorded contain few identified species and are dominated by the genus *Dicroidium*. As in the case of the Moolayember floras, the abundance of this genus indicates a Triassic age, but does not enable any more precise dating. Assignment of the Clematis Sandstone to the Lower Triassic by Phillips (1960, p. 281) is not established by the species listed by Hill (1957, p. 12), which are also known from younger strata; possibly this interpretation was influenced by stratigraphic, as well as purely floral evidence.

Previously published information on the Clematis microflora is confined to a report of the occurrence of species of *Alisporites* and *Aratrisporites* (Evans, 1966, p. 60). The present paper thus constitutes the first descriptive publication on the palynology of the formation and represents an extension of the study of microfloral assemblages from the Moolayember Formation (de Jersey and Hamilton, 1967). As in the case of the latter paper, study of the Clematis assemblages has been significantly assisted by previous publications on Australian Triassic microfloras; many of the species described in them are also present in the Clematis microflora. These previous publications are as listed by de Jersey and Hamilton (1967, p. 1), with the addition of the recent papers on the Wollar Sandstone of New South Wales (Helby, 1967) and Moolayember Formation (de Jersey and Hamilton, 1967).

In view of the lack of previous descriptive study, the initial objective of the present work has been to record genera and species present in the Clematis



assemblages. In doing so, particular attention has been paid, as regards description and illustration, to new species and species not previously recorded from Australia. The assemblages recorded furnish a basis for comparison with other Triassic microfloras; as in the case of the Moolayember Formation, such a comparison can be expected to provide evidence on the age of the Clematis Sandstone. Finally, a major objective has been to record the microfloral sequence within the formation. This biostratigraphic study has been based on the area where it attains its thickest development, so as to provide a reference succession, with which assemblages from thinner sections of the formation, elsewhere in the Bowen Basin, can be correlated.

### STRATIGRAPHIC DISCUSSION

The type locality for the Clematis Sandstone is the gorge of Clematis Creek (Phillips, 1960, p. 280). In this area, located in the southern part of the Expedition Range (see locality map—Figure 1), the thickness of the formation is about 800 to 1,000 feet. The sediments exposed in this range form part of the western limb of a large structure, the Mimosa Syncline, in which the Triassic formations of the Bowen Basin attain their maximum development. As mapped in the eastern limb of this structure, the Clematis Sandstone is somewhat thinner; in this area about 500 to 700 feet of strata, assigned to this formation, have been recorded (Tweedale, 1960, p. 281; Malone, 1964, p. 275).

In view of the maximum development of the formation in the Mimosa Syncline, the present investigation has been based on material from that structure. Such material should provide a more representative picture of the microfloral sequence in the formation than would samples from its thinner developments in other areas. The material studied has, of necessity, been derived from stratigraphic drillholes; this is because deep weathering in this part of Queensland renders surface samples unsuitable for palynological study.

Accordingly, samples used in the present investigation were obtained from two groups of stratigraphic holes, drilled in the eastern and western limbs of the Mimosa Syncline. These stratigraphic holes were drilled by the Department of Mines as part of its programme of stratigraphic drilling, carried out in 1966 and 1967. The results of the earlier portion of this programme have been recently summarised by Gray (1968). The fact that this drilling was undertaken with a rig capable of continuous coring, was particularly relevant to the present investigation. The bulk of the Clematis Sandstone consists of medium- to coarse-grained sandstone, samples of which usually give poor yields of plant microfossils; it is only from the thin beds of shale and

siltstone, interbedded within the sequence, that satisfactory yields of well preserved spores and pollen grains can be obtained. Continuous coring of the stratigraphic holes concerned has thus enabled effective recovery and sampling of material from these thin beds of finer sediments.

On the western side of the Mimosa Syncline, D.R.D. 9 and D.R.D. 11 (see locality map—Figure 1) were drilled in the upper and lower parts of the formation respectively. Of these D.R.D. 9 was cored continuously from 39 feet to total depth (912 feet); it thus provided material for study of the microfloral sequence from upper Clematis Sandstone to lower Moolayember Formation. Study of data from D.R.D. 9 shows that the boundary between the formations is gradational and difficult to establish precisely. It was originally placed at 379 feet in this hole (de Jersey and Hamilton, 1967, p. 2). Re-interpretation of additional evidence, derived mainly from petrological study of the sandstones, indicates that the boundary should be placed slightly lower, at a depth of approximately 411 feet (Gray, 1968, p. 13). In all 11 shale samples were obtained from the formation in this hole, thus covering the top 500 feet of the Clematis Sandstone. The other hole, D.R.D. 11, was cored continuously from 56 feet to total depth of 430 feet, in the lower part of the Clematis sequence. Unfortunately the strata penetrated were deeply weathered and although four samples were processed, they proved to be barren of plant microfossils. This deep weathering appears to be fairly general for lower Clematis sediments in this area.

On the eastern side of the syncline the Clematis sequence was sampled by three holes: D.R.D. 2, D.R.D. 4 and D.R.D. 16 (see locality map—Figure 1). Of these D.R.D. 2 cored the lower Moolayember—upper Clematis sequence, the formation boundary being placed tentatively at 64 feet in this hole (Gray, 1968, p. 6). Between this depth and the total depth of 251 feet, three shale samples were selected for study. The lower Clematis — upper Rewan sequence was sampled by D.R.D. 4. This hole was cored continuously from 49 feet to its total depth of 202 feet. The Clematis-Rewan boundary, which was gradational, was placed at 142 feet (Gray 1968, p. 6). Four samples of shale from the lower Clematis Sandstone in this hole were examined.

All the stratigraphic holes, mentioned above, were drilled during 1966. Study of assemblages from the lower and upper Clematis Sandstone, in D.R.D. 4 and D.R.D. 2 respectively, revealed marked differences in specific composition. In particular assemblages from D.R.D. 4 were characterised by the presence of *Aratrisporites tenuispinosus*, not observed in those from D.R.D. 2. In order to sample the strata intervening



between the sections penetrated by D.R.D. 2 and D.R.D. 4, an additional hole, D.R.D. 16, was drilled during 1967. It was sited at an intermediate location (see locality map—Figure 1) and was cored continuously from 33 feet to its total depth of 535 feet. The section sampled by this hole extended from a stratigraphic level equivalent to about 130 feet in D.R.D. 2 down to a level equivalent to 110 feet below the base of the section in D.R.D. 4 (A.R.G. Gray, pers. comm.). This hole thus achieved its primary objectives of sampling the section intervening between those in D.R.D. 2 and D.R.D. 4 and of enabling the distinctively different assemblages in each of these sections to be studied within one vertical stratigraphic section.

Taken collectively, the assemblages from the four holes—D.R.D. 2, D.R.D. 4, D.R.D. 9 and D.R.D. 16—have provided an overall picture of the microfloral sequence within the Clematis Sandstone in the Mimosa Syncline. On the eastern side of this structure, the upper part of the formation and its transition to the overlying Moolayember Formation have been sampled by D.R.D. 2, while D.R.D. 4 and D.R.D. 16 have sampled the middle and lower part of the formation and its transition to the underlying Rewan Formation. On the western side, D.R.D. 9 has provided coverage of the upper half of the Clematis Sandstone and of the basal part of the Moolayember Formation. As these holes were drilled in the area where the Clematis Sandstone attains its greatest thickness, it seems likely that the section sampled includes equivalents of the thinner developments of the formation in other areas and that the microfloral sequence studied represents the most complete succession available.

### PROCESSING OF SAMPLES

Methods used in processing the Clematis samples were largely dependent on the preservation of the spores and pollen grains. In this respect they could be divided into two groups. In the first group, comprising the majority of the samples studied, the preservation of the microflora was similar to that of the overlying Moolayember Formation. Accordingly methods similar to those followed in processing the Moolayember samples (de Jersey and Hamilton, 1967, p. 2) were employed. Specific gravity separation (in zinc chloride solution) had previously proved so successful in improving the proportions of spores and pollen grains in the maceration residues, that it was adopted as standard practice for these Clematis samples also. For this group of samples only mild oxidation with dilute nitric acid or with sodium hypochlorite solution was necessary.

The other group of samples included those from the section between the depths of 430 and 600 feet in D.R.D. 9. Maceration residues from these samples

were abnormal in that the spores and pollen grains were relatively dark and distinctly carbonized. They required more drastic oxidation (with Schulze solution), followed by treatment with sodium carbonate solution, to render them sufficiently translucent for study. In addition, processing was rendered more difficult by the relatively brittle nature of the carbonized exines, which prevented use of an ultrasonic vibrator, and by their higher density, which rendered specific gravity separation less effective. Generally, preservation of detail in representative species was inferior to that in the assemblages from the other group of samples. Because of this poorer preservation and these difficulties in processing, assemblages from some of these samples from D.R.D. 9 were studied in less detail than those from the other samples.

It is not clear from the evidence available, why spores and pollen grains from this group of samples should exhibit this carbonized type of preservation. Slight regional metamorphism appears to be excluded as an explanation, since assemblages from overlying and underlying strata in D.R.D. 9 are characterized by a more normal type of preservation. It can only be suggested that some change, of an unknown nature, in environment of deposition may have led to a different mode of preservation of the plant microfossils.

### CLASSIFICATION OF SPORES AND POLLEN GRAINS

The genera described in the succeeding section of this paper are arranged on the basis of the most recent suprageneric classification, that of Potonié (1966). Although this classification differs in certain respects from that used by Playford (1965), which was followed in the paper on the Moolayember Formation (de Jersey and Hamilton, 1967), it is considered beyond the scope of the present paper to attempt a comprehensive review of suprageneric classification. Use of Potonié's classification has facilitated arrangement of the descriptive portion of this paper; this classification has the additional advantage of being widely known to palynologists in various countries.

The investigation has been restricted to miospores; although a few megaspores have been observed in some of the assemblages they are relatively rare, often fragmentary and poorly preserved. Only one acritarch specimen was observed in all the assemblages studied, (in the sample from 92ft. 3in. in D.R.D. 4).

### SYSTEMATIC DESCRIPTIONS

|           |                                               |
|-----------|-----------------------------------------------|
| Anteturma | SPORITES H. Potonié, 1893                     |
| Turma     | TRILETES Reinsch <i>emend.</i> Dettmann, 1963 |



Subturma AZONOTRILETES Luber *emend.* Dettmann, 1963

Infraturma LAEVIGATI Bennie and Kidston *emend.* Potonié, 1956

Genus CONCAVISPORITES Pflug *emend.* Delcourt and Sprumont, 1955

*Type Species*:—*Concavisporites rugulatus* Pflug, 1953.

*Concavisporites tumidus* Playford, 1965

Plate 1, Figure 1

*Figured specimen*:—Slide S1484, stage co-ordinates 17.9, 90.8, diameter 58 microns. Co-ordinates of lower right hand corner of cover glass 26.2, 84.5.

*Locality*:—D.R.D. 16, 136ft. 6in.

*Remarks*:—The identification of the specimen figured with *C. tumidus* has been confirmed by Dr. Playford (pers. comm.). It is the only specimen of this species observed in the Clematis assemblages.

*Distribution*:—Upper Triassic of Brady Formation, Tasmania (Playford, 1965); Clematis Sandstone.

Genus CYATHIDITES Couper, 1953

*Type Species*:—*Cyathidites australis* Couper, 1953.  
*Cyathidites breviradiatus* Helby, 1967

Plate 1, Figure 2

*Figured specimen*:—Slide S1414, stage co-ordinates 12.1, 93.8, diameter 43 microns. Co-ordinates of lower right hand corner of cover glass 26.3, 84.3.

*Locality*:—D.R.D. 4, 92ft. 3in.

*Remarks*:—Apart from a somewhat wider size range (diameter, based on 24 measured specimens, from 33 to 56 microns) and slightly more variation in the length of the laesurae (from 1/3 to 2/3 spore radius) the Clematis specimens are indistinguishable from those described by Helby (1967, p. 63).

*Distribution*:—Triassic of upper Wollar Sandstone and upper Narrabeen Group (Helby, 1967); Clematis Sandstone.

Genus DICTYOPHYLLIDITES Couper *emend.* Dettmann, 1963

*Type species*:—*Dictyophyllidites harrisii* Couper, 1958.

*Dictyophyllidites harrisii* Couper, 1958

Plate 1, Figure 4

*Figured specimen*:—Slide S1492, stage co-ordinates 13.4, 83.7, diameter 53 microns. Co-ordinates of lower right hand corner of cover glass 27.3, 82.8.

*Locality*:—D.R.D. 16, 191ft.

*Remarks*:—As in the Moolayember assemblages (de Jersey and Hamilton, 1967, p. 5) this species is a rare component of the Clematis microfloras in comparison with *Dictyophyllidites mortoni*.

*Distribution*:—Jurassic of Great Britain (Couper, 1958); Upper Triassic of Austria (Bharadwaj and Singh, 1964); Lower Jurassic of Hungary (Góczán, 1956); Upper Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

*Dictyophyllidites mortoni* (de Jersey) Playford and Dettmann, 1965

Plate 1, Figure 5

*Figured specimen*:—Slide S1413, stage co-ordinates 7.7, 81.4, diameter 40 microns. Co-ordinates of lower right hand corner of cover glass 27.3, 81.3.

*Locality*:—D.R.D. 4, 92ft. 3in.

*Distribution*:—Triassic and Jurassic of south-east Queensland (de Jersey, 1959, 1962, 1963); Rhaetoliasic of Leigh Creek, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus LEIOTRILETES (Naumova) Potonié and Kremp, 1954

*Type species*:—*Leiotriletes sphaerotriangulus* (Loose) Potonié and Kremp, 1954.

*Leiotriletes directus* Balme and Hennelly, 1956

*Remarks*:—Spores of this simple, generalised type are common in many of the Clematis assemblages.

*Distribution*:—Widely distributed in the Permian, Triassic and Jurassic of Australia (e.g. Balme and Hennelly, 1956; de Jersey, 1959, 1962); Triassic of Antarctica (Norris, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus CALAMOSPORA Schopf, Wilson and Bentall, 1944

*Type species*:—*Calamospora hartungiana* Schopf in Schopf, Wilson and Bentall, 1944.

*Calamospora tener* (Leschik) de Jersey, 1962

Plate 1, Figure 3

*Figured specimen*:—Slide S1390, stage co-ordinates 10.0, 86.2, diameter 38 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 82.8.

*Locality*:—D.R.D. 9, 850ft. 3in.

*Remarks*:—This species is a rare component of the Clematis assemblages.



*Distribution*:—Upper Triassic of Switzerland (Leschik, 1955); Upper Triassic of Austria (Klaus, 1960); Triassic of Ipswich Coal Measures (de Jersey, 1962); Jurassic of Great Britain (Couper, 1958); Lower Keuper of West Germany (Mädler, 1964); Middle and Upper Triassic, and Lower Jurassic of East Germany (Schulz, 1966); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus *RETUSOTRILETES* Naumova, 1953

*Type species*:—*Retusotriletes simplex* Naumova, 1953.

*Retusotriletes junior* de Jersey and Hamilton, 1967

*Remarks*:—This species is quite rare in the Clematis assemblages.

*Distribution*:—Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus *STEREISPORITES* Pflug *emend.* de Jersey, 1964

*Type species*:—*Stereisporites stereoides* (Potonié and Venitz) Pflug, 1953.

*Stereisporites antiquasporites* (Wilson and Webster) Dettmann, 1963

Plate 1, Figure 6

*Figured specimen*:—Slide S1422, stage co-ordinates 12.0, 94.6, diameter 28 microns. Co-ordinates of lower right hand corner of cover glass 21.7, 84.0.

*Locality*:—D.R.D. 4, 56ft. 5in.

*Remarks*:—The specimen figured (Plate 1, Figure 6) is the only specimen of this species observed in the Clematis assemblages. As mentioned previously (de Jersey, 1964, p. 5) this species comprises spores of relatively simple morphology; an extended stratigraphic range, through several periods, is consequently to be expected.

*Distribution*:—Clematis Sandstone; Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Upper Triassic of Bundamba Group (de Jersey, 1964); Jurassic and Lower Cretaceous of Western Australia (Balme, 1957); Jurassic of Precipice Sandstone and lower Evergreen Formation, Surat Basin (de Jersey and Paten, 1964); Cretaceous of Western Canada (Pocock, 1962); Cretaceous of south-eastern Australia (Dettmann, 1963); Tertiary of Montana, U.S.A. (Wilson and Webster, 1946).

Infraturma *APICULATI* Bennie and Kidston *emend.* Potonié, 1956

Subinfraturma *VERRUCATI* Dybová and Jachowicz, 1957

Genus *CLAVATRILETES* Herbst, 1965

*Type species*:—*Clavatriletes hammenii* Herbst, 1965.

*Clavatriletes* sp. cf. *C. hammenii* Herbst, 1965

Plate 1, Figure 7

*Figured specimen*:—Slide S1375, stage co-ordinates 10.8, 93.2, diameter 49 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 82.0.

*Locality*:—D.R.D. 9, 856ft. 2in.

*Remarks*:—The specimen figured is similar in all respects to those previously recorded from the Moolayember Formation (de Jersey and Hamilton, 1967, pp. 6, 7). It is the only specimen, comparable with this species, observed in the present investigation.

Genus *CONVERRUCOSISPORITES* Potonié and Kremp, 1954

*Type species*:—*Converrucosisporites triquetrus* (Ibrahim) Potonié and Kremp, 1954.

*Remarks*:—In a recent paper Potonié (1966, p. 31) regards *Converrucosisporites* as a synonym of *Trilites* Cookson ex Couper, 1953. The writer, however, prefers to maintain *Converrucosisporites* as a distinct genus. This is because Couper's diagnosis of *Trilites* (1953, p. 29), which has not been formally emended, was of very broad circumscription and included species with diverse sculpture which would now be assigned to several form-genera. Accordingly, until the diagnosis of *Trilites* is formally emended and circumscribed more closely around its type species, the species recorded below, *C. cameroni* (de Jersey) Playford and Dettmann, is retained in *Converrucosisporites*.

*Converrucosisporites cameroni* (de Jersey) Playford and Dettmann, 1965

Plate 1, Figure 9

*Figured specimen*:—Slide S1482, stage co-ordinates 17.1, 87.0, diameter 41 microns. Co-ordinates of lower right hand corner of cover glass 27.1, 85.5.

*Locality*:—D.R.D. 16, 136ft. 6ins.

*Distribution*:—Triassic of Ipswich Coal Measures (de Jersey, 1962); Upper Triassic of Bundamba Group (de Jersey, 1964); Rhaeto-Liassic of Leigh Creek Coal Measures (Playford and Dettmann, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus *GUTTATISPORITES* Visscher, 1966

*Type species*:—*Guttatisporites guttatus* Visscher, 1966.

*Guttatisporites visscheri* sp. nov.

Plate 1, Figures 8, 10 and 11

*Diagnosis*:—Amb sub-circular or convexly sub-triangular. Diameter (based on 21 measured specimens)



41 to 66 microns. Trilete; laesurae distinct, inconspicuous or indefinite, where evident relatively straight and extending about  $\frac{3}{4}$  spore radius, without significant development of lips. Distal and equatorial exine with dense sculpture of verruca-like elements, with polygonal to irregular outlines. Sculptural elements variable in size and shape within each specimen, basically about 2 to 5 microns in basal diameter, about 1.5 microns high; larger elements usually present, apparently formed by coalescence of these basic elements. Pits and channels between sculptural elements relatively narrow (width 1 micron or less), forming a negative reticulum. Similar sculpture extending on to proximal exine in equatorial region, for a width about equal to that of sculptural elements, i.e., up to about 5 microns; remainder of proximal exine smooth.

*Holotype* (Plate 1, Figures 10, 11—proximal, distal foci):—Slide S1489, stage co-ordinates 25.0, 98.5; diameter 44 microns. Co-ordinates of lower right hand corner of cover glass 27.7, 83.4.

*Locality*:—D.R.D. 16, 175ft. 2in.

*Figured specimen* (Plate 1, Figure 8—distal focus):—Slide S1426, stage co-ordinates 15.4, 98.3; diameter 53 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 83.5.

*Locality*:—D.R.D. 2, 93ft. 7in.

*Remarks*:—As pointed out by Visscher (1966, p. 331) *Guttatisporites* differs from *Verrucosporites* Ibrahim *emend.* Smith *et al.*, 1964, in having closely packed verruca-like elements, which have irregular polygonal to crenulate outlines and are variable in size and shape. Some of them appear to merge together to form larger elements; between the elements there is a negative reticulum.

The Queensland specimens show some superficial similarity to *Convolutispora* Hoffmeister, Staplin and Malloy, 1955 and spores of this species were tentatively assigned to that genus in a study of microfloras from the Moolayember Formation (de Jersey and Hamilton, 1967). However detailed study of the sculpture shows that the elements are basically verruca-like, rather than ridge-like, so that the specimens are more appropriately placed in *Guttatisporites*. Although the Queensland spores differ from the three species described by Visscher (1966, pp. 332, 333) in having the sculptural elements confined to the distal and equatorial regions, it is not considered that this difference warrants their exclusion from *Guttatisporites*. This is because in one of the described species, *G. elegans* Visscher, there is evidence for reduction in size of the proximal sculptural elements. The Queensland spores are considered to represent an extreme case of this trend, resulting in a largely unsculptured proximal exine. Consequently the specimens recorded here are assigned to *Guttatisporites*,

on the basis of a broad interpretation of the development of proximal sculpture in the genus. In other respects they are basically similar to *Guttatisporites*, particularly in the characteristic nature of the distal sculptural elements.

The illustrations of the holotype (Plate 1, Figures 10, 11) indicate, in proximal focus, the inconspicuous trilete mark and, in distal focus, the characteristic sculptural elements. The latter are well illustrated by another specimen in distal focus (Plate 1, Figure 8). As indicated above, *Guttatisporites visscheri* sp. nov. is distinguished from the other three species assigned to the genus (Visscher, 1966, pp. 332, 333) by its largely smooth proximal exine. It also differs from them in having a smaller equatorial diameter. Other features on which the distinction can be based are the less conspicuous laesurae, and absence of echina-bearing verrucae in *G. visscheri*. The specific name refers to Dr. H. Visscher, of Utrecht, in recognition of his discovery of *Guttatisporites* and of his significant contributions to knowledge of Triassic microfloras.

*Distribution*:—Clematis Sandstone; lower Moolayember Formation.

Genus RUGULATISPORITES Pflug, in Thomson and Pflug, 1953

*Type species*:—*Rugulatisporites quintus* Thomson and Pflug, 1953.

*Rugulatisporites trisinus* de Jersey and Hamilton, 1967

*Remarks*:—On the basis of its fairly regular rugulae and lack of tectate laesurae, this species has been assigned to *Rugulatisporites* rather than to *Lycopodiacidites* Couper, *emend.* Potonié, 1956. It is very rare in the Clematis assemblages; on the available evidence, identifiable specimens are confined to the upper part of the formation.

*Distribution*:—Middle Triassic of Lower Moolayember Formation (de Jersey and Hamilton, 1967); upper Clematis Sandstone.

Subinfraturma NODATI Dybová and Jachowicz, 1957

Genus APICULATISPORIS Potonié and Kremp, 1956

*Type species*:—*Apiculatisporis aculeatus* (Ibrahim) Potonié, 1956.

*Apiculatisporis clematissi* sp. nov.

Plate 1, Figure 12

*Diagnosis*:—Amb circular or sub-circular. Equatorial diameter (based on 9 measured specimens) 40 to 66 microns. Trilete; laesurae straight, distinct or inconspicuous; where evident without any significant develop-



ment of lips. Exine with dense sculpture, predominantly conical, showing gradation to verrucae and spinae. Sculptural elements mainly discrete, rarely confluent, fairly evenly distributed on both surfaces of exine. Individual elements about 1.5 to 3 microns in basal diameter, height about 2 to 3 microns, about 1 to 2 microns apart. Exine, between projections, laevigate, about 1 to 2 microns in thickness, frequently with randomly disposed folds.

*Holotype* (Plate 1, Figure 12—equatorial focus):—Slide S1371, stage co-ordinates 22.2, 93.5; diameter 40 microns. Co-ordinates of lower right hand corner of cover glass 26.4, 80.4.

*Locality*:—D.R.D. 9, 856ft. 2in.

*Remarks*:—Among other species recorded from the Triassic of Australia, *Apiculatisporis globosus* (Leschik) Playford and Dettman, 1965 differs from these Clematis specimens, in having laesurae with distinct lips, and also more sparsely distributed sculptural elements. *Anapiculatisporites cooksonae* Playford, 1965 is distinguished by having sculpture confined to the distal exine, as well as by possessing lipped laesurae, while *Acanthotriletes bradiensis* Playford, 1965 also differs in having a distinctly triangular amb and very prominent laesurae. Spores from Permo-Triassic transition beds, described by Hennelly (1958, p. 364) as *Apiculatisporites bulliensis* are significantly smaller than *A. clematidis*, and have smaller sculptural elements and a comparatively thick exine.

With regard to other Triassic species, *Apiculatisporis lanjouwii* Jansonius, 1962, from the Lower Triassic of Canada, resembles *A. clematidis* in having laesurae which are often ill defined, but is appreciably smaller, and has more densely packed projections, which do not appear to exhibit the diversity of shape evident in the Queensland species. The Upper Triassic species *Apiculatisporites spiniger* Leschik, 1955 has somewhat similar sculptural elements which are, however, unevenly distributed, being reduced or absent on the proximal exine. No close comparison can be made with species of *Apiculatisporis* described from periods other than Triassic.

*Distribution*:—Clematis Sandstone.

Genus LOPHOTRILETES (Naumova) Potonié and Kremp, 1954

*Type species*:—*Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp, 1954.

*Lophotriletes bauhinae* de Jersey and Hamilton, 1967

Plate 2, Figure 3

*Figured specimen*:—Slide S1426, stage co-ordinates 23.7, 90.8, diameter 43 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 83.5.

*Locality*:—D.R.D. 2, 93ft. 7in.

*Remarks*:—This species is a characteristic component of microfloras from the lower half of the Moolayember Formation (de Jersey and Hamilton, 1967, Fig. 2). It has been observed in assemblages from horizons distributed through the Clematis sequence.

*Distribution*:—Lower Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus OSMUNDACIDITES Couper, 1953

*Type species*:—*Osmundacidites wellmanii* Couper, 1953.

*Remarks*:—Because of the poor preservation of many of the Clematis specimens of *Osmundacidites*, specific identification has not been attempted, except in the case of a few specimens assigned to *O. wellmanii*.

*Osmundacidites wellmanii* Couper, 1953

*Remarks*:—Specimens of this species, in the Clematis microflora, are similar to those previously recorded from the Moolayember Formation (de Jersey and Hamilton, 1967, p. 5; pl. 2, fig. 7).

*Distribution*:—Jurassic and Cretaceous of Great Britain, New Zealand (Couper, 1953, 1958, 1960); Rhaeto-Liassic of Leigh Creek, South Australia (Playford and Dettmann, 1965); Upper Mesozoic of south-eastern Australia (Dettmann, 1963); Cretaceous of western Canada (Pocock, 1962); Jurassic of Surat Basin (de Jersey and Paten, 1964); Jurassic of Marburg Sandstone (de Jersey, 1963); Upper Triassic of Bundamba Group (de Jersey, 1964); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Subinfraturma BACULATI Dybová and Jachowicz, 1957

Genus NEORAISTRICKIA Potonié, 1956

*Type species*:—*Neoraistrickia truncata* (Cookson) Potonié, 1956.

*Neoraistrickia* sp. cf. *N. taylorii* Playford and Dettmann, 1965

*Remarks*:—Specimens in the Clematis assemblages differ slightly from *N. taylorii* Playford and Dettmann, 1965, in having sculptural elements which are somewhat larger in mean basal diameter and are also more closely spaced. For this reason they are compared, rather than identified, with that species. Spores of this type are relatively rare in the material studied, so that it has not been possible to determine whether there is continuous gradation to specimens identifiable with *N. taylorii*.



*Distribution of N. taylorii*:—Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Upper Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967).

Infraturma MURORNATI Potonié and Kremp, 1954

Genus FOVEOSPORITES Balme, 1957

*Type species*:—*Foveosporites canalis* Balme, 1957.  
*Foveosporites mimosae* de Jersey and Hamilton, 1967

*Remarks*:—Only one specimen identifiable with this species has been observed in the present investigation.

*Distribution*:—Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus TIGRISPORITES Klaus, 1960

*Type species*:—*Tigrisporites halleinis* Klaus, 1960.  
*Tigrisporites playfordi*, de Jersey and Hamilton, 1967

*Remarks*:—A few specimens of this species are present in the Clematis assemblages. They are similar in all significant features to those described from the Moolayember Formation (de Jersey and Hamilton, 1967, p. 10). The size range of the Clematis specimens (mean diameter, based on 8 measured specimens) is from 24 to 43 microns.

*Distribution*:—Triassic of Tiers Formation, Tasmania (Playford, 1965); Middle Triassic of lower Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Turma ZONALES Bennie and Kidston *emend.* Potonié, 1956

Subturma AURITOTRILETES Potonié and Kremp, 1954

Infraturma AURICULATI Schopf *emend.* Dettmann, 1963

Genus INDOSPORA Bharadwaj, 1962, *emend.*

*Type species*:—*Indospora clara* Bharadwaj, 1962.

*Emended diagnosis*:—Amb triangular or sub-triangular, sides straight, slightly concave or convex. Trilete; laesurae, without significant development of lips, terminate before reaching equator. Radial extremities of laesurae terminated proximally by muri or auriculate projections. Muri or auriculate projections extend to distal exine, where a structure is formed, in distal radial and polar regions, composed of muri or rugulae, or a combination of both. Discrete sculptural elements (additional to muri and rugulae) may be present and include grana, coni, verrucae, spinae and bacula, all confined to distal and equatorial regions. Remainder of proximal exine smooth or finely punctate.

*Remarks*:—The diagnosis of Bharadwaj (1962, p. 82), which was based largely on the type species *Indospora clara* Bharadwaj, 1962, is here emended to provide adequate circumscription for a group of species, possessing certain common morphological features. A characteristic feature of these species is the distal structural complex in the polar and radial regions, composed of muri or rugulae or a combination of both. This structure extends at the angles on to the proximal exine, in the form of muri or auriculae. Distally a reticulum, perfect or imperfect, may be developed.

The main reasons for emending the diagnosis of Bharadwaj are (1) to provide for species such as *Indospora macula* Bharadwaj and Salujha, 1964 and *I. reticulata* sp. nov., described below, in which the structures at the angles are auriculate projections, rather than muri, and extend only a limited distance distally before giving rise to a reticulum and (2) to provide for more variation in the nature of the discrete distal sculpture. The species *I. reticulata* sp. nov. shows a gradation from the verrucose and baculate elements specified by Bharadwaj (1962, p. 82) to granulate, conate and spinose elements, which are accordingly included in the diagnosis. Grana and coni are also represented in the sculptural elements, of *Indospora* sp., described by Bharadwaj and Salujha (1964, p. 196).

The species described by Bharadwaj (1962, p. 83) and Bharadwaj and Salujha (1964, pp. 195, 196) came from the Upper Permian of the Raniganj coalfield, in India. The present record of two species from the Clematis Sandstone thus extends the known stratigraphic range of the genus into the Triassic.

*Indospora clara* Bharadwaj, 1962

Plate 2, Figures 8 and 9

*Description (based on Queensland specimens)*:—Amb triangular or sub-triangular, sides straight, slightly concave or convex. Diameter (based on 10 measured specimens) 33 to 51 microns. Three prominent distal muri present, about 3 to 7 microns in width in optical section. Muri, with subsidiary muri, may form a reticulum in distal polar region, comprising a few (up to about 5) lumina. Discrete sculpture, confined to distal and equatorial region, consisting of verrucae, coni, bacula and spinae. Basal diameter of verrucae and coni about 1.5 to 3 microns, bacula and spinae about 2 to 4 microns long, basal diameter about 1.5 microns. Bacula with rounded, truncated or divided extremities. Sculptural elements about 2 to 3 microns apart. Trilete; laesurae, without significant development of lips, straight or slightly curved, inconspicuous to distinct, are terminated near equator by distal muri, which extend somewhat on to proximal exine. Proximal exine (apart from equatorial region) smooth, relatively thin.



*Figured specimen* (Plate 2, Figure 9—equatorial focus):—Slide S1485, stage co-ordinates 9.1, 96.8; diameter 51 microns. Co-ordinates of lower right hand corner of cover glass 27.0, 83.8.

*Locality*:—D.R.D. 16, 136ft. 6in.

*Figured specimen* (Plate 2, Figure 8—equatorial focus):—Slide S1462, stage co-ordinates 11.0, 88.9; diameter 47 microns. Co-ordinates of lower right hand corner of cover glass 26.8, 83.8.

*Locality*:—D.R.D. 16, 32ft. 6in.

*Remarks*:—The specimens recorded here are indistinguishable specifically from *Indospora clara* Bharadwaj, 1962. Variation in the distal polar reticulum and in the spacing of the discrete sculptural elements, mentioned by Bharadwaj (1962, pp. 82, 83), is also a feature of the Queensland specimens. In the latter the verrucae and bacula, mentioned in the description of the type material, show a gradation to conate and spinose elements, in some cases. The specimens figured (Plate 2, Figures 8 and 9) are most closely comparable with Pl. 3, Fig. 56 of Bharadwaj (1962) in the development and spacing of the bacula; with regard to the distal polar reticulum, they show a close resemblance to Pl. 3, Figs. 54 and 55 of that author.

Dr. Bharadwaj (pers. comm.) has confirmed that these spores come within the range of variation of *I. clara* in sculptural features. He has also pointed out that they are slightly smaller than specimens he assigned to that species. However this lesser size may be related to maceration procedures, and, taken alone, is not regarded by the writer as a feature by which the Queensland specimens could be separated from *I. clara*.

*Distribution*:—Upper Permian of Raniganj coalfield, India (Bharadwaj, 1962); Triassic of Clematis Sandstone, uppermost Rewan Formation.

*Indospora reticulata* sp. nov.

Plate 2, Figures 1, 2, 4 and 5

*Diagnosis*:—Amb triangular or sub-triangular, sides straight, slightly concave or convex, equatorial outline slightly modified by projecting sculpture. Diameter (based on 15 measured specimens) 38 to 58 microns. Trilete; laesurae straight or slightly curved, without significant development of lips, terminate before reaching equator. Radial extremities of laesurae terminated proximally by auriculate projections, of variable shape, about 5 to 10 microns in average diameter. Auriculate projections joined distally in radial and polar regions by sculpture consisting dominantly of rugulate elements, about 1.5 to 3 microns in width, 1 to 2 microns high.

Distal sculpture forming a reticulum, with lumina 3 to 7 microns in diameter. Interradial distal and equatorial regions also with discrete sculptural elements, mainly coni, but also including grana, verrucae, bacula and spinae. Discrete elements about 1 to 3 microns in basal diameter, 1 to 3 microns apart, may also be sparsely represented in distal polar region. Proximal exine (apart from equatorial region) laevigate or finely punctate.

*Holotype* (Plate 2, Figures 4, 5—distal and equatorial foci):—Slide S1474, stage co-ordinates 6.7, 97.0; diameter 48 microns. Co-ordinates of lower right hand corner of cover glass 26.4, 83.0.

*Locality*:—D.R.D. 16, 88ft. 2in.

*Figured specimen* (Plate 2, Figures 1, 2—distal and equatorial foci):—Slide S1470, stage co-ordinates 6.6, 90.8; diameter 41 microns. Co-ordinates of lower right hand corner of cover glass 25.6, 83.0.

*Locality*:—D.R.D. 16, 69ft. 9ins.

*Remarks*:—The main variation in this species is in the nature of the distal reticulum. In some specimens this is largely perfect, being composed of polygonal lumina; the holotype (Plate 2, Figure 4) approaches this condition, although it is not an extreme case. The reticulum includes a greater proportion of imperfect elements in other specimens (Plate 2, Figure 1). Other features in which appreciable variation is shown are the extent of the distal reticulum and, conversely, the proportion of the distal exine ornamented solely by discrete elements. There is also variation in the size and shape of the auriculate projections.

Four species of *Indospora* have been described previously, one by Bharadwaj (1962, p. 83) and three by Bharadwaj and Salujha (1964, pp. 195, 196), all from the Upper Permian of the Raniganj coalfield, India. Of these, *I. macula* Bharadwaj and Salujha, 1964 shows closest resemblance to the Clematis specimens, in having a somewhat similar distal reticulum. It differs, however, in having sparsely distributed discrete elements (grana and bacula); in the Clematis species the discrete elements are more numerous, particularly in the interradian equatorial regions, and also include coni and verrucae. In addition the reticulate sculpture occupies a greater proportion of the distal exine in *I. reticulata* than in *I. macula*.

The differences between *I. reticulata* and other species of *Indospora*, including *I. clara* (recorded above) are more marked. These species differ from *I. reticulata* and *I. macula* in lacking an extensive distal reticulum; apart from discrete elements their distal structures are formed mainly by three prominent muri, the reticulate sculpture being subordinate and, if present, confined to the distal polar region.



*Distribution*:—Lower Clematis Sandstone, uppermost Rewan Formation.

Subturma ZONOTRILETES Waltz, 1935

Infraturma CINGULATI Potonié and Klaus, 1954

Genus DENSOISPORITES Weyland and Krieger *emend.* Dettmann, 1963

*Type species*:—*Densoisporites velatus* Weyland and Krieger *emend.* Krasnova, 1961.

*Densoisporites playfordi* (Balme) Dettmann, 1963

*Remarks*:—A few poorly preserved specimens of this species have been observed in the Clematis assemblages.

*Distribution*:—Lower and (?) Middle Triassic of Western Australia (Balme, 1963); Lower Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus NEVESISPORITES de Jersey and Paten, 1964

*Type species*:—*Nevesisporites vallatus* de Jersey and Paten, 1964.

*Nevesisporites limatulus* Playford, 1965

Plate 3, Figure 2

*Figured specimen (proximal focus)*:—Slide S1415, stage co-ordinates 11.4, 90.0; diameter 36 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 81.0.

*Locality*:—D.R.D. 4, 92ft. 3in.

*Remarks*:—This species ranges through the complete thickness of the Clematis Sandstone. The identification of the specimen figured (Plate 3, Figure 2) has been confirmed by Dr. Playford (pers. comm.).

*Distribution*:—Triassic of Tiers Formation, Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus STENOZONOTRILETES (Naumova) Hacquebard, 1957

*Type species*:—*Stenozonotriletes conformis* Naumova, 1953.

*Stenozonotriletes* sp.

Plate 3, Figure 5

*Figured specimen*:—Slide S1390, stage co-ordinates 7.0, 97.6; diameter 30 microns. Co-ordinates of lower right hand corner of cover glass 26.5; 82.8.

*Locality*:—D.R.D. 9, 850ft. 3in.

*Remarks*:—Three specimens, assigned to *Stenozonotriletes*, have been observed in the Clematis assem-

blages. The specimen figured (Plate 3, Figure 5) resembles *Stenozonotriletes simplex* Naumova, described from the Devonian of Russia (Naumova, 1953, pp. 36, 69, 130) in its triangular outline, smooth exine and overall size. It differs from that species, however, in having distinctly lipped laesurae. The laesurae do not widen on joining the cingulum as in *Asterocalamotriletes* (Luber) *emend.* Potonié 1958; for this reason assignment to *Stenozonotriletes* is preferred.

*Distribution*:—Clematis Sandstone.

Infraturma ZONATI Potonié and Kremp, 1954

Genus KRAEUSELISPORITES Leschik *emend.* Jansonius, 1962

*Type species*:—*Kraeuselisporites dentatus* Leschik, 1955.

*Kraeuselisporites differens* Helby, 1967

Plate 3, Figure 1

*Figured specimen*:—Slide S1462, stage co-ordinates 19.3, 97.8; diameter 59 microns. Co-ordinates of lower right hand corner of cover glass 26.8, 83.9.

*Locality*:—D.R.D. 16, 32ft. 6in.

*Remarks*:—The specimen figured (Plate 3, Figure 1) is identified with *Kraeuselisporites differens* on the basis of its close conformity to the description and figures of that species (Helby, 1967, p. 65; pl. 2, figs. 23-27). This specimen, and those figured by Helby, differ from the Moolayember species *K. verrucifer* de Jersey and Hamilton, 1967, in exhibiting distinct thickening at the base of the zona, with which is associated closer spacing of the sculptural elements. However in view of the relative rarity of *Kraeuselisporites* in the Clematis and Moolayember assemblages, which have been examined, insufficient specimens are available to explore fully any possibility of a gradation between them in these features.

There is some stratigraphic evidence to support the distinction between the species. *K. verrucifer* was recorded only from near the top of the Moolayember sequence (de Jersey and Hamilton, 1967, p. 56) while *K. differens* has been observed in Clematis, but not in Moolayember assemblages. On the available evidence, a stratigraphic interval of over 5,000 feet thus separates the known occurrences of the two species in the Triassic of Queensland.

*Distribution*:—Triassic of Wollar Sandstone, New South Wales (Helby, 1967); Clematis Sandstone.

Turma MONOLETES Ibrahim, 1933

Subturma AZONOMONOLETES Luber, 1935

Infraturma SCULPTATOMONOLETI Dybová and Jachowicz, 1957



Genus ARATRISPORITES Leschik *emend.* Playford and Dettmann, 1965

*Type species*:—*Aratrisporites parvispinosus* Leschik *emend.* Playford, 1965.

*Aratrisporites plicatus* de Jersey and Hamilton, 1967

Plate 5, Figure 7

*Figured specimen*:—Slide S1427, stage co-ordinates 18.1, 87.0; overall dimensions 59 x 40 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 79.5.

*Locality*:—D.R.D. 2, 93ft. 7in.

*Remarks*:—Specimens of this species have been recorded from horizons distributed through the stratigraphic thickness of the Clematis Sandstone. They are similar in all essential features to those of the species, previously described from the Moolayember Formation (de Jersey and Hamilton, 1967, p. 13). The size range of the Clematis specimens (based on 13 measured specimens) is length (overall) 46 to 79 microns, breadth (overall) 35 to 59 microns. Because of the thin, delicate nature of the sculptine, many examples of this species are broken, or distorted by folding; the specimen figured (Plate 5, Figure 7) is one of the few complete, unfolded spores, assigned to this species in the Clematis assemblages.

*Distribution*:—Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

*Aratrisporites* sp. cf. *A. rotundus* Mädlar, 1964

Plate 5, Figure 8

*Figured specimen*:—Slide S1498, stage co-ordinates 14.8, 101.9; dimensions 31 x 25 microns. Co-ordinates of lower right hand corner of cover glass 27.3, 83.0.

*Locality*:—D.R.D. 16, 351ft.

*Remarks*:—The specimen figured (Plate 5, Figure 9) is a typical representative of specimens characterised by their small size, thin sclerine, broadly ovate to sub-circular outline and finely granular sculpture, which are widely distributed in the Clematis Sandstone and overlying Moolayember Formation. Such specimens closely resemble those of *Aratrisporites rotundus* illustrated by Mädlar (1964, pl. 9, figs. 19, 20). However, in view of the apparent gradation in the Moolayember assemblages to specimens with distinct external conate-spinulate sculpture, recorded by de Jersey and Hamilton (1967, p. 13), these spores are compared, rather than identified with *A. rotundus*, for which infra-granulate sculpture was specified (Mädlar, 1964, p. 106).

*Distribution of A. rotundus*:—Lower Keuper of Germany (Mädlar, 1964); Upper Muschelkalk, Lower and Middle Keuper of East Germany (Schulz, 1966).

*Distribution of Aratrisporites* sp. cf. *A. rotundus*:—Lower Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

*Aratrisporites strigosus* Playford, 1965

*Remarks*:—A few poorly preserved specimens, assigned to this species, have been observed in the Clematis assemblages.

*Distribution*:—Triassic of Tiers and Brady Formations, Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

*Aratrisporites tenuispinosus* Playford, 1965

Plate 5, Figure 9

*Figured specimen*:—Slide S1422, stage co-ordinates 16.7, 91.8; dimensions 36 x 25 microns (excluding spines). Co-ordinates of lower right hand corner of cover glass 21.7, 84.0.

*Locality*:—D.R.D. 4, 56ft. 5in.

*Remarks*:—Identification of the Clematis specimens with this species is supported by Dr. Playford (pers. comm.). They are similar to the Tasmanian spores described by that author (Playford, 1965, p. 196), except that the Queensland specimens are generally somewhat smaller. For the latter the overall dimensions (exclusive of spines), based on 54 measured specimens, are length, 23 to 40 microns, breadth 15 to 26 microns. The overall dimensions of spores from the type locality are quoted as length 34 to 49 microns, breadth 26 to 37 microns. As the Tasmanian and Queensland specimens are so similar in morphological features, the smaller size of the latter is considered significant only in extending the known size range of the species.

*Affinity*:—Very similar, possibly conspecific spores have been obtained from the Lycopsid genus *Cyclostrobus* Helby and Martin, 1965.

*Distribution*:—Triassic of Tiers Formation, Tasmania (Playford, 1965); basal Clematis Sandstone.

*Aratrisporites wollariensis* Helby, 1967

Plate 5, Figure 5

*Figured specimen*:—Slide S1498, stage co-ordinates 16.1, 100.8; overall dimensions 33 x 25 microns. Co-ordinates of lower right hand corner of cover glass 27.3, 83.0.

*Locality*:—D.R.D. 16, 351ft.

*Remarks*:—Characteristic features of this species are its small size, fine sculpture and the folding at the margin of the inner layer (intexine). A few specimens have been observed in the basal portion of the Clematis Sandstone; the species appears to be more common in



assemblages from the underlying Rewan Formation, as indicated by study of samples from the uppermost portion of the Rewan sequence.

*Affinity*:—Helby (1967, p. 68) suggests possible derivation of these spores from a *Lycopsid* strobilus of the *Lycostrobus* type.

*Distribution*:—Wollar Sandstone (upper portion), Collaroy Claystone and Hawkesbury Sandstone of New South Wales (Helby, 1967); basal Clematis Sandstone, uppermost Rewan Formation.

*Aratrisporites* sp. A

Plate 5, Figure 6

*Figured specimen*:—Slide S1469, stage co-ordinates 7.9, 100.2; overall dimensions 56 x 51 microns, inner layer 31 x 31 microns. Co-ordinates of lower right hand corner of cover glass 27.0, 83.2.

*Locality*:—D.R.D. 16, 69ft. 9in.

*Remarks*:—The specimen figured (Plate 5, Figure 6) closely resembles a spore recorded as *Aratrisporites* sp. from the Moolayember Formation (de Jersey and Hamilton, 1967, p. 14). Characteristic features are the fine sculpture and small inner layer, in relation to the overall equatorial dimensions. Although these two specimens are regarded as probably conspecific, insufficient specimens have been observed to justify formal taxonomic treatment.

*Distribution*:—Lower Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus *POLYPODIISPORITES* Potonié and Gellétich ex Potonié, 1956

*Type species*:—*Polypodiisporites favus* (Potonié) Potonié and Gellétich, 1933.

*Remarks*:—Potonié has recently (1966, p. 104) regarded this genus as a synonym of *Polypodiisporites* Ross, 1949. However Playford and Dettmann (1965) regard the genera as distinct. They state (1965, p. 150) "*Verrucatosporites* Pflug, 1953 and its probable synonym *Polypodiidites* Ross ex Couper, 1953 are distinguishable from *Polypodiisporites* in possessing markedly reduced proximal sculpture". The latter interpretation is followed here.

*Polypodiisporites ipsviciensis* (de Jersey) Playford and Dettmann, 1965

*Remarks*:—Specimens of this species from the Clematis Sandstone are similar in all respects to those described and figured from other Triassic assemblages in Queensland, comprising the Ipswich Coal Measures (de Jersey, 1962, p. 7), Bundamba Group (de Jersey, 1964, p. 8) and Moolayember Formation (de Jersey and Hamilton, 1967, p. 12).

*Distribution*:—Triassic of Ipswich Coal Measures (de Jersey, 1962); Upper Triassic of Bundamba Group (de Jersey, 1964); Triassic of Moorooka and Tingalpa Formations, Brisbane area (de Jersey and Hamilton, 1965); Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Lower Triassic of Ross Formation, Tasmania (Playford, 1965); Triassic of Wollar Sandstone, New South Wales (Helby, 1967); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus *PUNCTATOSPORITES* Ibrahim, 1933

*Type species*:—*Punctatosporites minutus* Ibrahim, 1933.

*Punctatosporites walkomi* de Jersey, 1962

*Remarks*:—This species is a rare component of the Clematis assemblages.

*Distribution*:—Triassic of Ipswich Coal Measures (de Jersey, 1962); Upper Triassic of Bundamba Group (de Jersey, 1964); Triassic of Moorooka and Tingalpa Formations, Brisbane area (de Jersey and Hamilton, 1965); Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Anteturma *POLLENITES* Potonié, 1931

Turma *SACCITES* Erdtman, 1947

Subturma *MONOSACCITES* Chitaley *emend.* Potonié and Kremp, 1954

Infraturma *TRILETESACCITI* Leschik, 1955

Subinfraturma *INTRORNATI* Butterworth and Williams, 1958

Genus *GUTHOERLISPORITES* Bharadwaj, 1954

*Type species*:—*Guthoerlisporites magnificus* Bharadwaj, 1954.

*Guthoerlisporites cancellosus* Playford and Dettmann, 1965

Plate 3, Figure 3

*Figured specimen*:—Slide S1418, stage co-ordinates 10.9, 91.0; equatorial diameter 101 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 82.6.

*Locality*:—D.R.D. 2, 188ft. 3in.

*Remarks*:—Rare specimens of this species have been observed in the Clematis assemblages. The identification of the specimen figured (Plate 3, Figure 3) has been confirmed by Dr. Playford (pers. comm.).



*Distribution*:—Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965); Clematis Sandstone.

Genus PARASACCITES Bharadwaj and Tiwari, 1964

*Type species*:—*Parasaccites korbaensis* Bharadwaj and Tiwari, 1964.

*Parasaccites* sp.

*Remarks*:—Only three specimens, referable to this genus, have been observed. In morphological features and size range (diameter 99-155 microns) they show a general similarity to specimens of *Parasaccites* present in Queensland microfloras of Permian age. In view of the poor preservation of the few specimens available, specific assignment has not been attempted. The possibility must be considered, that these specimens may have been reworked from Permian sediments.

*Distribution*:—Clematis Sandstone.

Infraturma ALETESACCITI Leschik, 1955

Genus ACCINCTISPORITES Leschik, 1955

*Type species*:—*Accinctisporites ligatus* Leschik, 1955.

*Accinctisporites ligatus* Leschik, 1955

Plate 3, Figures 4 and 6

*Figured specimen* (Plate 3, Figure 6):—Slide S1494, stage co-ordinates 10.1, 95.4; diameter 91 microns. Co-ordinates of lower right hand corner of cover glass 27.6, 83.4.

*Locality*:—D.R.D. 16, 191ft.

*Figured specimen* (Plate 3, Figure 4):—Slide S1376, stage co-ordinates 11.9, 85.2; diameter 76 microns. Co-ordinates of lower right hand corner of cover glass 26.8, 82.2.

*Locality*:—D.R.D. 4, 96ft. 8in.

*Remarks*:—Apart from a slightly wider size range (diameter 44 to 92 microns—based on 10 measured specimens), the Clematis specimens, assigned to this species, are similar in all respects to those previously described from the Moolayember Formation (de Jersey and Hamilton, 1967, p. 14).

Superficially grains of this species may appear similar to those of *Parasaccites*, a widespread genus in Permian sediments. They can be distinguished from the latter, however, by the lack of a trilete mark, the absence of a radial pattern in the saccus reticulum, the generally smaller overall size and also by the different type of saccus attachment. The difference in saccus attachment between the two genera is illustrated by contrasting that of *Accinctisporites*, described by

Clarke (1965a, pp. 303, 304), with that of *Parasaccites*, described by Bharadwaj and Tiwari (1964, p.p. 143, 144). The conformity of the type of saccus attachment to that described by Clarke is illustrated by one of the specimens figured (Plate 3, Figure 4).

*Distribution*:—Middle Keuper of Switzerland (Leschik, 1955); Lower Keuper of Germany (Mädler, 1964); Lower Keuper of Worcestershire, England (Clarke, 1965a); Middle and Upper Triassic of East Germany (Schulz, 1966); Middle Triassic of Moolayember Formation; Clematis Sandstone.

Subturma DISACCITES Cookson, 1947

Genus ALISPORITES Daugherty, 1941

*Type species*:—*Alisporites opii* Daugherty, 1941.

*Remarks*:—Specimens assigned to this genus are abundant in the Clematis assemblages. In general morphology and preservation they are similar to those recorded from the Moolayember Formation, regarding which it was stated (de Jersey and Hamilton, 1967, p. 14): "As in the case of similar grains from the Ipswich Coal Measures (de Jersey, 1962, pp. 7-9) it is considered that many of them have affinities with the microsporophyll *Pteruchus*, of the Corystospermaceae, and thus with leaf fossils assigned to *Dicroidium* and allied genera. Because of wide variation, pollen grains of this type are difficult to group into specific categories, moreover it seems unlikely that any such grouping would be easy to apply to the many poorly preserved specimens encountered".

Consequently, the procedure followed has been similar to that adopted in the paper on the Moolayember Formation. That is, apart from well preserved, suitably oriented specimens, assigned to the species recorded below, specific differentiation of the other grains has not been attempted, and they are listed as "*Alisporites* spp."

*Alisporites australis* de Jersey, 1962

Plate 3, Figure 8

*Figured specimen*:—Slide S1424, stage co-ordinates 25.8, 82.8; total span 73 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 82.4.

*Locality*:—D.R.D. 4, 56ft. 5in.

*Distribution*:—Triassic of Ipswich Coal Measures (de Jersey, 1962); Upper Triassic of Bundamba Group (de Jersey, 1964); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Jurassic of Precipice Sandstone, Evergreen Formation and Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.



*Alisporites townrovi* Helby, 1967

## Plate 3, Figure 7

*Figured specimen*:—Slide S1410, stage co-ordinates 15.0, 96.7; total span 74 microns. Co-ordinates of lower right hand corner of cover glass 26.0, 84.9.

*Locality*:—D.R.D. 4, 127ft. 7in.

*Remarks*:—The specimen figured (Plate 3, Figure 7) is the only specimen, assigned to this species, observed in the assemblages studied.

*Distribution*:—Wollar Sandstone of New South Wales (Helby, 1967, p. 68); lower Clematis Sandstone.

Genus CHORDASPORITES Klaus, 1960

*Type species*:—*Chordasporites singulichorda* Klaus, 1960.

*Remarks*:—This genus has been variously classified within the Subturmae Disaccites (Visscher, 1966, p. 346) and Striatites (Potonié, 1966, p. 130). The writer prefers Visscher's interpretation, as he considers that the characteristic "chorda" is more analagous to a fold structure than to the taeniae of the Striatites.

*Chordasporites australiensis* de Jersey, 1962

## Plate 4, Figures 1 and 3

*Figured specimen* (Plate 4, Figures 1, 3—proximal, distal foci):—Slide S1426, stage co-ordinates 20.1, 85.5; total span 83 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 83.5.

*Locality*:—D.R.D. 2, 93ft. 7in.

*Remarks*:—The specimen figured is representative of grains of this species, which ranges sporadically through the Clematis Sandstone. Superficially such specimens may appear similar to *Alisporites townrovi* Helby. However, Plate 4, Figures 1 and 3, focussed on the proximal and distal attachments of the sacchi respectively, show that the ridge (chorda) across the corpus is a proximal feature, extending completely across the corpus between the proximal attachments. In this respect it differs from the distal "bridge" of exoexine often present in *A. townrovi*. In addition the latter species usually exhibits a distinct, lipped colpus, not observed in *C. australiensis*.

*Distribution*:—Triassic of Ipswich Coal Measures (de Jersey, 1962); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus LIMITISPORITES Leschik *emend.* Potonié 1958

*Type species*:—*Limitisporites rectus* Leschik, 1956.

*Limitisporites* sp.

## Plate 3, Figure 9

*Figured specimen*:—Slide S1334, stage co-ordinates 24.0, 96.7; total span 63 microns. Co-ordinates of lower right hand corner of cover glass 26.8, 84.6.

*Locality*:—D.R.D. 9, 491ft. 11in.

*Remarks*:—The specimen figured is the only representative of this genus, observed in the assemblages studied. Because of its poor preservation, specific identification has not been attempted. In particular, the sculpture of the proximal region of the corpus is obscured by pitting reminiscent of bacterial degradation patterns described by Elsik (1966, pp. 515, 516). For this reason full comparison cannot be made with species of *Limitisporites*, in which the granulate sculpture of the corpus is an important character in specific differentiation, as illustrated by the work of Klaus (1963, p. 284).

*Distribution* (one specimen):—Upper Clematis Sandstone.

Genus PLATYSACCUS Naumova ex Potonié and Klaus, 1954

*Type species*:—*Platysaccus papilionis* Potonié and Klaus, 1954.

*Platysaccus queenslandi* de Jersey, 1962

## Plate 3, Figure 10

*Figured specimen*:—Slide S1373, stage co-ordinates 9.5, 84.7; total span 76 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 82.6.

*Locality*:—D.R.D. 9, 856ft. 2in.

*Remarks*:—This species ranges through the complete thickness of the Clematis Sandstone.

*Triassic*:—Triassic of Ipswich Coal Measures (de Jersey, 1962); Upper Triassic of Bundamba Group (de Jersey, 1964); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus SULCATISPORITES Leschik *emend.* Mädlar, 1964

*Type species*:—*Sulcatisporites interpositus* Leschik, 1955.

*Remarks*:—Mädlar's emended diagnosis of *Sulcatisporites* (1964, p. 63) is preferred to that of Bharadwaj (1962, p. 98) because it does not include the relative distinctness of the corpus as a diagnostic requirement. This feature was regarded by the latter author (1962, p. 97) as one of the criteria by which the genus could



be distinguished from *Alisporites* Daugherty. The writer considers, however, that the distinctness of the outline of the corpus, in bisaccate grains of this type, is likely to be significantly affected by preservation and maceration procedures. A sounder basis for distinction from *Alisporites* should be provided by the narrow distal cleft between the sacchi and their smaller size, as well as by the overall sub-circular outline of *Sulcatisporites* in polar view.

*Sulcatisporites* sp. cf. *S. krauseli* Mädler, 1964

Plate 4, Figure 6

*Figured specimen*:—Slide S1413, stage co-ordinates 15.2, 92.9; overall dimensions 51 x 48 microns. Co-ordinates of lower right hand corner of cover glass 27.3, 81.3.

*Locality*:—D.R.D. 4, 92ft. 3in.

*Remarks*:—The specimen figured (Plate 4, Figure 6) resembles *S. krauseli* Mädler (Mädler, 1964, pp. 65, 66) in having a fine saccus reticulum and also in the relative dimensions and shape of the corpus and sacchi. However, as only one specimen is available, it is compared, rather than identified, with the European species. *Sulcatisporites krauseli* differs from *S. ovatus* (Balme and Hennelly) Bharadwaj, 1962 in having an overall subcircular outline, in contrast to the more oval shape of the latter species, which also appears to have a coarser saccus reticulum.

*Distribution of Sulcatisporites krauseli*:—Upper Bunter Sandstone; lower Muschelkalk and lower Keuper of West Germany (Mädler, 1964); Upper Bunter Sandstone and lower Muschelkalk of East Germany (Schulz, 1966).

Genus *SULCOSACCISPORA* Klaus, 1964

*Synonym*:—*Caytoniidites* Malyavkina, 1964.

*Type species*:—*Sulcosaccispora minuta* Klaus, 1964.

*Remarks*:—*Caytoniidites* Malyavkina, 1964, a monotypic genus based on the species *C. alaticonformis* Malyavkina, 1964, closely resembles *Sulcosaccispora* and is regarded as synonymous. As the description of *Sulcosaccispora* appeared in April 1964 and that of *Caytoniidites* was published in November of that year, the former genus has chronological priority.

*Sulcosaccispora alaticonformis* (Malyavkina, 1964),  
comb. nov.

Plate 4, Figure 8

*Synonym*:—1967. *Sulcosaccispora lata* de Jersey and Hamilton, pp. 15, 16, pl. 8, figs. 1-4.

*Figured specimen*:—Slide S1492, stage co-ordinates 11.7, 96.0, dimensions 38 x 31 microns. Co-ordinates of lower right hand corner of cover glass 27.3, 82.8.

*Locality*:—D.R.D. 16, 191ft.

*Remarks*:—*Sulcosaccispora lata* is indistinguishable from *Caytoniidites alaticonformis*, described from the Middle Triassic of Chelyabinsk, Siberia, by Malyavkina (1964, p. 93; pl. 5, fig. 9; pl. 7, fig. 10). As *Sulcosaccispora* has chronological priority over *Caytoniidites*, the species is transferred to the former genus as a new combination. It is relatively rare in the Clematis Sandstone.

*Distribution*:—Lower and Middle Triassic of U.S.S.R. (Malyavkina, 1964); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus *TRIADISPORA* Klaus, 1964

*Type species*:—*Triadispora plicata* Klaus, 1964.

*Remarks*:—Distinguishing features of *Triadispora*, according to Klaus (1964, p. 120) are the presence of a trilete mark on the corpus, surrounded by a distinctly ornamented area, as well as the sub-equatorial attachment and slight distal inclination of the sacchi. The writer is in agreement with Klaus (1964) and Visscher (1966) that *Triadispora* can be maintained as a genus, distinct from *Illinites* Kosanke, *emend.* Klaus, 1964. On the basis of re-examination of the genotype of the latter, Klaus (1964, p. 127) established its generic characters as (1) the entirely granulate nature of the proximal corpus; (2) a reduced trilete mark, the N.-S. ray being reduced in length, while the other two extend almost to the margin of the corpus; and (3) the presence of two subsidiary laesurae near the equatorial edges of the corpus.

Of these characters, the first listed is shared by *Triadispora* and *Illinites* and the presence of a reduced trilete mark has been reported by Visscher in *Triadispora crassa* (1966, p. 351), although in most specimens assigned to *Triadispora* the trilete mark is not significantly reduced. However, no sign of the two subsidiary laesurae, which also characterize *Illinites*, has been reported in species of *Triadispora*; the presence or absence of this feature appears to provide a reliable means of generic differentiation. The distinction between the genera is also reflected in their stratigraphic distribution; *Illinites* is known from the Carboniferous and Permian, as well as the Triassic, while described species of *Triadispora* are confined to Triassic assemblages.

Another bisaccate genus which exhibits a trilete mark is *Angustisulcites* Freudenthal *emend.* Visscher, 1966. This genus differs from *Illinites* in having diploxylonoid, not haploxylonoid sacchi and in having two lateral laesurae located equatorially. The latter feature readily differentiates it from *Triadispora*. Two other genera with a tetrad mark on the corpus are *Jugasporites* Leschik *emend.* Klaus, 1963 and *Limitisporites* Leschik



*emend.* Potonié, 1958. Both are readily distinguished from *Triadispora* by the reduced character of the trilete mark and its location in a smooth or slightly ornamented area. These features also characterise *Eridospollenites parvus*, the genotype of *Eridospollenites* Freudenthal, 1964, which should be regarded as a synonym of *Limitisporites* Leschik *emend.* Potonié, 1958 (see Visscher, 1966, p. 353). Finally, *Bharadwajispora* Jansonius, 1962 is distinguished by its prominent trilete mark, which is characterized by curved laesurae, with distinctive associated folds (Jansonius, 1962, p. 53). These features are not observed in any species of *Triadispora*.

From the stratigraphic aspect, the discovery of *Triadispora* in the Triassic of Australia is of considerable interest. The presence of two European species—*T. crassa* and *T. falcata* in the Clematis Sandstone indicates wide geographic distribution of these Triassic species. It seems likely that, when their stratigraphic ranges are fully explored, they will be useful in correlation of the relevant portions of the Triassic sequences of Europe and Australia. Although, in the Queensland samples so far examined, *Triadispora* is much less common than in some of the European material studied by Klaus and Visscher, this lesser abundance may be a reflection of local environmental conditions during deposition. A general discussion on the significance of *Triadispora*, and other species, in correlation of the Triassic of Queensland and Europe will be found in a later section of this paper.

*Triadispora crassa* Klaus, 1964

Plate 4, Figure 7

*Description (based on Queensland specimens):*—Bisaccate pollen grains. Total span (based on 7 measured specimens) 53 to 99 microns. Corpus dark in colour, outline sub-circular or broadly oval, mean diameter about 30 to 44 microns. Proximal region of corpus with a distinct trilete mark; laesurae approximately equal in length. Cappa finely infra-granulate to almost smooth; distal germinal area smooth. Sacci with sub-equatorial diploxylonoid attachment, exhibit slight distal inclination; distal attachments well defined. Sacci variable in shape and size; in shape from approximately semi-circular to sub-circular; in size from approximately equal to corpus to appreciably larger. Sacci with a fine indistinct internal reticulum (diameter of lumina about 1 micron).

*Figured specimen (oblique equatorial view):*—Slide S1413, stage co-ordinates 18.9, 100.5; total span 59 microns. Co-ordinates of lower right hand corner of cover glass 27.3, 81.3.

*Locality:*—D.R.D. 4, 92ft. 3in.

*Remarks:*—The Queensland specimens are identified with this European species, on the basis of the descrip-

tions and figures of Klaus (1964, p. 122) and Visscher (1966, p. 350).

The species has been observed through the basal 350 feet of the Clematis Sandstone (in assemblages from D.R.D. 16). It is also present in the upper part of the Rewan Formation, having been observed at least 100 feet below the top of the Rewan sequence in a preliminary, incomplete study of samples from that formation.

*Distribution:*—Upper Bunter Sandstone of France (Klaus, 1964); Upper Bunter Sandstone of the Netherlands (Visscher, 1966); Upper Bunter Sandstone of East Germany (Schulz, 1966); Carnian of Austria (Kavary, 1966); lower Clematis Sandstone and uppermost Rewan Formation.

*Triadispora falcata* Klaus, 1964

Plate 4, Figure 2

*Description (based on Clematis specimens):*—Bisaccate pollen grains. Total span (based on 10 measured specimens) 56 to 82 microns. Corpus slightly darker than sacci, outline sub-circular or broadly oval, mean diameter about 40 to 45 microns. Proximal region of corpus with a distinct trilete mark; laesurae approximately equal in length. Cappa infra-granulate; distal germinal area smooth. Saccus attachment haploxylonoid, frequently with transverse folds at the saccus bases. Sacci attached sub-equatorially, with little, if any distal inclination. Sacci with an indistinct internal reticulum (diameter of lumina about 1 to 1.5 microns), shape roughly semi-circular, in size somewhat smaller than corpus.

*Figured specimen (Polar view):*—Slide S1317, stage co-ordinates 23.1, 88.0; total span 63 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 82.9.

*Locality:*—D.R.D. 9, 431ft. 2in.

*Remarks:*—Specific identification of these specimens is based on the descriptions and figures of Klaus (1964, p. 121) and Visscher (1966, p. 352).

The species has been observed in assemblages from near the top of the formation, in D.R.D. 9; it has also been found in a sample from D.R.D. 4, 56ft. 5in., near the base of the unit. Its range thus virtually extends through the complete thickness of the Clematis Sandstone.

*Distribution:*—Upper Bunter Sandstone of France (Klaus, 1964); upper Bunter Sandstone and Muschelkalk of Germany and Austria (Klaus, 1965); upper Bunter Sandstone of the Netherlands (Visscher, 1966); Clematis Sandstone.

*Triadispora* sp. cf. *T. muelleri* (Reinhardt and Schmitz) Visscher, 1966



## Plate 4, Figure 4

*Figured specimen (Polar view):*—Slide S1497, stage co-ordinates 9.4, 90.0; overall diameter 71 microns, diameter of corpus 61 microns. Co-ordinates of lower right hand corner of cover glass 27.1, 82.8.

*Locality:*—D.R.D. 16, 351ft.

*Remarks:*—As only one specimen has been observed, it is compared, rather than identified, with this species, although it has many features in common with specimens described by Reinhardt and Schmitz (1964, p. 612) and Visscher (1966, p. 352).

Visscher's transference of the species from *Nuskoisporites* to *Triadispora* is supported here. He has reported the occurrence of transitional forms showing the gradation between it and *T. crassa* (1966, p. 349); hence it is closely related to that species and more appropriately assigned to *Triadispora*. As Visscher points out (1966, p. 352) creation of a new trisaccate genus would obscure this close relationship with *T. crassa*. It might even be questioned whether it is desirable to regard these trisaccate grains as a species distinct from *T. crassa*. However, Visscher considers (1966, p. 352) that "*T. muelleri* differs from these transitional forms by its relatively bigger central body, by the less projecting oval sacchi (in polar view), by the rather distinct bladder bases and by the very characteristic distal bladder interconnections". As he has studied numerous specimens of these species his opinion is followed by the writer.

In Europe the species has been recorded only from the Röt (upper Bunter Sandstone) of Germany and the Netherlands. The single Clematis specimen came from near the base of the formation, in D.R.D. 16.

*Distribution:*—Upper Bunter Sandstone of Thüringia, Germany (Reinhardt, 1964b); upper Bunter Sandstone of the Netherlands (Visscher, 1966); upper Bunter Sandstone of East Germany (Schulz, 1966); basal Clematis Sandstone. (cf.)

Genus *VITREISPORITES* Leschik *emend.* Jansonius, 1962

*Type species:*—*Vitreisporites signatus* Leschik, 1955.

*Vitreisporites microsaccus* de Jersey, 1964

## Plate 4, Figure 9

*Figured specimen:*—Slide S1329, stage co-ordinates 14.9, 91.2; total span 25 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 83.4.

*Locality:*—D.R.D. 9, 491ft. 4in.

*Distribution:*—Upper Triassic of Bundamba Group (de Jersey, 1964); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

*Vitreisporites pallidus* (Reissinger) Nilsson, 1958.

## Plate 4, Figure 10

*Figured specimen:*—Slide S1493, stage co-ordinates 8.0, 88.0; total span 38 microns. Co-ordinates of lower right hand corner of cover glass 27.5, 81.2.

*Locality:*—D.R.D. 16, 191ft.

*Distribution:*—Widely distributed in the Jurassic of Europe and North America; Lower Triassic of Western Australia (Balme, 1963); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Jurassic of Surat Basin, Queensland (de Jersey and Paten, 1964); Jurassic of Walloon Coal Measures and Marburg Sandstone (de Jersey, 1959), 1963); Jurassic and Lower Cretaceous of Western Australia (Balme, 1957); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus *VOLTZIAEASPORITES* Klaus, 1964

*Type species:*—*Voltziaceasporites heteromorpha* Klaus, 1964.

*Voltziaceasporites heteromorpha* Klaus, 1964

## Plate 5, Figure 1

*Figured specimen (lateral view):*—Slide S1473, stage co-ordinates 14.0, 91.0; total span 79 microns. Co-ordinates of lower right hand corner of cover glass 26.4, 85.0.

*Locality:*—D.R.D. 16, 88ft. 2in.

*Remarks:*—The Queensland specimens conform closely to the description and figures of Klaus (1964, p. 129). Their size range (total span, based on 9 measured specimens) is from 66 to 97 microns. The mean diameter of the intexine varies from about 25 to 50 microns.

The discovery of this species in Australian assemblages indicates that it probably had a wide geographic distribution in Triassic microfloras. In Europe it first appears in the upper Bunter Sandstone, where it is a persistent, often abundant species, continuing in rare proportions into the overlying Muschelkalk and being observed occasionally in the Keuper (Klaus, 1964, p. 129).

In Queensland it has been observed to range through a section about 300 feet in thickness at the base of the Clematis Sandstone. Specimens have also been observed in a section, at least 150 feet in thickness, at the top of the underlying Rewan Formation; the lower limit of its range in this unit has yet to be determined. The relationship in age of the Clematis Sandstone to the European Triassic sequence, based on the distribution of *V. heteromorpha* and other distinctive species, is discussed in a later section of this paper.



*Affinity*:—Klaus (1964, p. 129) mentions the possible affinity of this species with the Triassic Voltziaceae.

*Distribution*:—Upper Bunter Sandstone, Muschelkalk and Keuper of Austria, Germany and France (Klaus, 1964, 1965); upper Bunter Sandstone of the Netherlands (Visscher, 1966); upper Bunter Sandstone and Muschelkalk of East Germany (Schulz, 1966); lower Clematis Sandstone and uppermost Rewan Formation.

Subturma STRIATITES Pant, 1954

Genus HAMIAPOLLENITES Wilson, 1962

*Type species*:—*Hamiapollenites saccatus* Wilson, 1962.

*Hamiapollenites insculptus* Playford and Dettmann, 1965

Plate 5, Figure 2

*Figured specimen*:—Slide S1499, stage co-ordinates 11.7, 84.6; total span 68 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 83.3.

*Locality*:—D.R.D. 16, 351ft.

*Remarks*:—This species is a rare component of the Clematis assemblages. It has been recorded from horizons distributed through the stratigraphic thickness of the formation. The identification of the specimen figured (Plate 5, Figure 2) is supported by Dr. Playford (pers. comm.).

*Distribution*:—Triassic of Leigh Creek Coal Measures (Playford and Dettmann, 1965); Triassic of Ipswich Coal Measures (Hill, Playford and Woods, 1965); Middle Triassic of lower Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Genus STRIATISACCUS Mädlar, 1964

*Type species*:—*Striatissaccus goswicensis* Mädlar, 1964.

*Remarks*:—Visscher (1966, pp. 357-358, 360-362) has summarized the taxonomic history of *Taeniaesporites* and allied genera. He emphasized the significance of the presence or absence of a monolete mark on the intexine, in generic classification (1966, p. 362). The importance of this feature was also indicated independently by Mädlar (1964, pp. 56, 57). Although full confirmation of the taxonomic value of this feature has yet to be obtained, the writer favours provisional acceptance of the fundamental generic grouping, recognized by Mädlar and Visscher, and based partly on the use of the intexinal mark in classification. Such acceptance will enable any stratigraphic evidence, bearing on the subject, to be evaluated.

Many previous workers, who did not attach significance to the presence of an intexinal mark, have assigned specimens, similar in generic features to *Striatissaccus*, to the genus *Taeniaesporites*. Concerning the latter, Visscher (1966, pp. 357, 358) has brought forward convincing evidence for regarding it as a synonym of *Lunatisporites*. Briefly stated, the evidence is as follows: Bharadwaj (February 1962) first united the genera *Lunatisporites* Leschik, 1955 and *Taeniaesporites* Leschik, 1955, regarded also by other authors (Jansonius, Hart, Visscher, etc.) as synonymous. He chose the name *Lunatisporites*; consequently, in accordance with the International Code of Botanical Nomenclature, "his choice must be followed".

The type species of *Lunatisporites*, *L. acutus* Leschik (= *Taeniaesporites krausei* Leschik, 1956) has an alete intexine. Visscher (1966, pp. 360-362) proposed a new genus, *Taeniaepollenites*, for specimens similar to *Lunatisporites* in many other features, but having a monolete intexine. Independently, in an earlier publication, Mädlar (1964, p. 56) proposed the genus *Striatissaccus*. Mädlar's diagnosis for the latter would include the species assigned by Visscher to *Taeniaepollenites*. The latter constitutes a somewhat broader generic grouping than *Striatissaccus*, which includes bisaccate grains in which the taeniae are usually subdivided. In *Taeniaepollenites* this subdivision is confined to the polar taeniae, which may break up into secondary taeniae. However, as *Striatissaccus* has chronological priority over Visscher's genus, the writer favours its retention, although he considers that it should be interpreted broadly, to include species with undivided polar taeniae, such as *Taeniaesporites novimundi* Jansonius, 1962. In accordance with this broad concept, *T. novimundi* is transferred to *Striatissaccus* Mädlar, without formal emendation of the latter.

*Striatissaccus novimundi* (Jansonius) comb. nov.

Plate 5, Figure 3

*Selected synonymy*:—

1962. *Taeniaesporites novimundi* Jansonius, p. 63, pl. 13, figs. 19-24.

1963. cf. *Taeniaesporites noviaulensis* Leschik (Balme p. 28, pl. 6, figs. 4-6).

1964. *Taeniaesporites novimundi* Jansonius (Klaus, p. 128, pl. 2, fig. 16).

1964. *Taeniaesporites noviaulensis* Leschik (Freudenthal, p. 226, pl. 4, figs. 4, 5).

1965. *Taeniaesporites novimundi* Jansonius (Clarke, p. 334, pl. 44, figs. 1, 2).



*Diagnosis* (Jansonius 1962, p. 63):—

“Size: overall: 50(71) 95 x 30(40) 60 microns  
central body: 30(46)60 x 25(38) 55 microns  
bladder: 17(24)33 x 26(40) 60 microns  
distance between  
bladder bases: 10(20) 30 microns.

Overall outline subcylindrical with slightly broadened ends; central body sub-angular oval to circular, bladder approximately half-circular in shape, joining central body flush or at a very obtuse angle, intra-marginal overlap 30-40%; central body moderately thick, proximally with four taeniae (6-7 microns), the inner ones usually strongly inflated (secondary folding when compressed) showing an infra-reticulum slightly less distinct than on bladders; bladders almost as thick as central body, proximally attached along equator (often a narrow dark area), distal bases faintly curved along a dark line reaching equator: reticulum moderately coarse, faintly radial especially near distal bladder base”.

*Figured specimen*:—Slide S1409, stage co-ordinates 20.3, 99.1; total span 82 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 85.6.

*Locality*:—D.R.D. 4, 127ft. 7in.

*Remarks*:—The Clematis specimens conform closely to the above diagnosis and are also closely comparable with the illustration of the holotype (Jansonius, 1962, pl. 13, fig. 19). Their size range (total span, based on 10 measured specimens) is from 61 to 94 microns.

Some authors, such as Hart (1964, p. 1189) and Freudenthal (1964, p. 226) regard *Taeniaesporites novimundi* Jansonius, 1962 as a synonym of *Taeniaesporites noviaulensis* Leschik, 1956; others, such as Klaus (1964, p. 128) and Clarke (1965, p. 334) regard these species as distinct. The writer supports the latter view, as expressed by Clarke (1965, p. 333): “*T. noviaulensis* differs from *T. novimundi* Jansonius in the shape of the spore body, the large sacchi and the coarser infrareticulum”. This is illustrated by the Clematis specimens, which are much closer to *T. novimundi* in these features than to *T. noviaulensis*. The former is also regarded as a distinct species by Schulz (1966, Table 5c).

*Taeniaesporites novimundi* is here transferred to *Striatissaccus* Mädlar as a new combination, as a mono-lete intexinal mark has been recorded in the species by Schulz (1966, Table 5c) and also in specimens described by Balme (1963, pl. 6, figs. 4-6) and Freudenthal (1964, pl. 4, figs. 3-5), considered by the writer to be conspecific with *T. novimundi*. As indicated above, placing of the species in *Striatissaccus* is consistent with a broad interpretation of Mädlar's genus. A mono-lete mark has not been observed in the Clematis

specimens; however these are poorly preserved and in many cases (as in the specimen figured—Plate 5, Figure 3) the intexine is missing.

*Distribution*:—Lower Triassic of Western Canada (Jansonius, 1962); Lower Triassic of Western Australia (Balme, 1963); Bunter Sandstone of Austria and Muschelkalk of Italy, France and Germany (Klaus, 1964); Bunter Sandstone of the Netherlands (Freudenthal, 1964); Permian of England (Clarke, 1965b); Lower Keuper of East Germany (Schulz, 1966).

Genus TUBANTIAPOLLENITES Visscher, 1966

*Type species*:—*Tubantiapollenites striatitoides* Visscher, 1966.

cf. *Tubantiapollenites striatitoides* Visscher, 1966

Plate 5, Figure 4

*Figured specimen*:—Slide S1492, stage co-ordinates 9.0, 100.6; total span 66 microns. Co-ordinates of lower right hand corner of cover glass 27.3, 82.8.

*Locality*:—D.R.D. 16, 191ft.

*Remarks*:—The specimen figured is the only one observed, comparable with *T. striatitoides*. It resembles Visscher's species in overall size, in the sub-circular outline of the corpus (in polar view), in the number of taeniae (about 7 visible in the Clematis specimen) and in the shape of the small haploxytonoid sacchi. No definite intexinal tetrad mark can be observed; for this reason the specimen is compared, rather than identified, with the European species. For the same reason it cannot be definitely assigned to the genus *Tubantiapollenites*.

*Distribution of T. striatitoides*:—Upper Bunter Sandstone of Hengelo, the Netherlands (Visscher, 1966).

Turma ALETES Ibrahim, 1933

Subturma AZONÁLETES Luber *emend.* Potonié and Kremp, 1954

Infraturma PSILONAPITI Erdtman, 1947

Genus GREBESPORA Jansonius, 1962

*Type species*:—*Grebepora concentrica* Jansonius, 1962.

*Remarks*:—This genus is here placed in the Turma Aletes, rather than in the Turma Triletes as was done by Potonié (1966, p. 23), because according to the generic diagnosis (Jansonius, 1962, p. 83) the genus is restricted to alete forms. No indication of a trilete mark has been observed in Queensland specimens assigned to *Grebepora concentrica*; in Canadian specimens of this species, in which a faint suggestion of a trilete mark was occasionally observed, this appears to have been a vestigial structure.



*Grebespora concentrica* Jansonius, 1962

## Plate 4, Figure 5

*Figured specimen*:—Slide S1484, stage co-ordinates 9.9, 86.0; diameter 30 microns. Co-ordinates of lower right hand corner of cover glass 26.2, 84.5.

*Locality*:—D.R.D. 16, 136ft. 6in.

*Remarks*:—This species is a rare component of the Clematis assemblages.

*Distribution*:—Lower Triassic of Western Canada (Jansonius, 1962); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

Turma PLICATES Naumova *emend.* Potonié, 1960

Subturma POLYPPLICATES Erdtman, 1952

Genus EQUISETOSPORITES Daugherty, 1941 *emend.* Pocock and Jansonius, 1964

*Type species*:—*Equisetosporites chinleana* Daugherty, 1941.

*Remarks*:—Grains of this type, including a specimen from the overlying Moolayember Formation, were previously assigned to *Ephedripites* (de Jersey and Hamilton, 1967, p. 19). This opinion must now be revised, in the light of additional information supplied by Dr. Jansonius (pers. comm.). Dr. Jansonius points out that pollen grains of this type have been variously assigned to the genera *Gnetaceaepollenites* Thiergart, 1938, *Equisetosporites* Daugherty, 1941, *Ephedripites* Bolchovitina, 1953 and to the modern genus *Ephedra* (by Scott, 1960, p. 271). He also considers that it is unwarranted to assign these grains to *Ephedra*; the writer agrees that attribution of dispersed Triassic pollen specimens to this modern genus is inappropriate.

Regarding the Tertiary genus *Gnetaceaepollenites*, Wilson (1962, pp. 31, 32) and Klaus (1963, p. 344) have pointed out that Permian and Triassic grains of this ephedroid type do not show striations in the median furrow which Potonié (1958, pp. 87, 88) regarded as a diagnostic feature of that genus. Dr. Jansonius has also mentioned (pers. comm.) that the holotype of its type species, though poorly preserved, is definitely not ephedroid, but probably of angiospermous affinity. Consequently *Equisetosporites* becomes the earliest name validly applied to fossil pollen grains of ephedroid type, and thus has priority over *Ephedripites* Bolchovitina, 1953. In accepting *Equisetosporites* as the generic name, the writer is in agreement with Dr. Jansonius, who supports this view by data on the original type of *Equisetosporites* and by study of a sample from the Chinle Formation, very close to Daugherty's original location. The grains from this sample are very similar in aspect and preservation to

*Equisetosporites* (Jansonius, pers. comm.) It should also be pointed out, finally, that although the name *Equisetosporites* is misleading in that it is wrongly suggestive of equisetalean affinities, it cannot be invalidated on these grounds alone.

*Affinity*:—As pointed out by several of the authors cited above, the structure of these grains indicates affinity with the Gnetales.

*Equisetosporites steevesi* (Jansonius), comb. nov.

## Plate 2, Figures 6 and 7

1962. *Gnetaceaepollenites steevesi* Jansonius, p. 77, pl. 15, figs. 28-33.

1967. *Ephedripites steevesi* (Jansonius) de Jersey and Hamilton, p. 19, pl. 9, fig. 7.

*Description (based on Clematis specimens)*:—Overall outline rounded oval: dimensions (based on 5 measured specimens): length 38 to 53 microns, breadth 20 to 25 microns. Exoexine with about 10 to 14 ribs (about 5 to 7 visible on one face), each about 2 to 3 microns in average width, more or less fused near longitudinal ends. Grooves between ribs about 1 to 1.5 microns in width. Exoexine may be tightly attached to intexine (Plate 2, Figure 6) or separated at longitudinal ends (Plate 2, Figure 7).

*Figured specimen (Plate 2, Figure 6)*:—Slide S1419, stage co-ordinates 13.2, 102.3; dimensions 41 x 20 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 85.6.

*Locality*:—D.R.D. 2, 188ft. 3in.

*Figured specimen (Plate 2, Figure 7)*:—Slide S1469, stage co-ordinates 8.8, 95.5; dimensions 43 x 25 microns. Co-ordinates of lower right hand corner of cover glass 27.0, 83.2.

*Locality*:—D.R.D. 16, 69ft. 9in.

*Remarks*:—As indicated above, *Equisetosporites* Daugherty, 1941 is regarded as the earliest generic name validly applied to grains of this type. Consequently the species *Gnetaceaepollenites steevesi* Jansonius, 1962, is here transferred, as a new combination, to that genus.

The specimens from the Clematis Sandstone conform, in all essential diagnostic features, to the description and illustrations of *E. steevesi* by Jansonius (1962). This is supported by Dr. Jansonius, who considers that both grains figured (Plate 2, Figures 6 and 7) fall within the range of variation of that species (pers. comm.). He has also kindly supplied a microslide containing specimens of *E. steevesi* for comparison; study of these specimens also indicates that the Queensland grains are identifiable with that species.



In one of the specimens figured (Plate 2, Figure 7) some separation of the inner layer is evident—a feature reminiscent of *G. scottii* Jansonius, 1962. However the same author considers (pers. comm.) that the inner layer of these gymnospermous pollen grains may shrink differentially within the sexinal outer layer, often turning darker in the process, so that the latter species may be no more than a preservational variant of *E. steevesi*. In any case the separation of the layers in the Clematis specimen is much less marked than in the figured specimens of *G. scottii*; in this feature a continuous gradation is evident between it and other grains assigned to *E. steevesi*.

Subturma MONOCOLPATES (Wodehouse) Iversen and Troels-Smith, 1953

Genus CYCADOPITES Wodehouse ex Wilson and Webster, 1946

*Type species*:—*Cycadopites follicularis* Wilson and Webster, 1946.

*Cycadopites nitidus* (Balme) de Jersey, 1964  
Plate 2, Figure 10

*Figured specimen*:—Slide S1371, stage co-ordinates 19.9, 92.4; dimensions 41 x 26 microns. Co-ordinates of lower right hand corner of cover glass 26.4, 80.5.

*Locality*:—D.R.D. 9, 856ft. 2in.

*Remarks*:—Balme (1957, p. 30) described this species from the Jurassic and Cretaceous of Western Australia. He distinguished it from the Permian *Entylissa vetus* Balme and Hennelly by its smaller size and thinner exine. Size distribution studies on Queensland material (de Jersey, 1962, p. 12; 1959, p. 359) indicate that specimens assigned to *C. nitidus* have a continuous size range, overlapping that of the Permian species. The effective criterion for distinguishing the species thus becomes the exine thickness. Regarding this feature, the Clematis specimens have thinner exines, in conformity with *C. nitidus*; consequently they are retained in that species.

*Distribution*:—Upper Jurassic and Lower Cretaceous of Western Australia (Balme, 1957); Cretaceous of south-eastern Australia (Dettmann, 1963); Jurassic of Wallon Coal Measures, Marburg Sandstone (de Jersey, 1959, 1963); Rhaetic of Hungary (Venkatachala and Góczán, 1964); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Upper Triassic of Tasmania (Playford, 1965); Upper Triassic of Bundamba Group, Queensland (de Jersey, 1964); Triassic of Ipswich Coal Measures (de Jersey, 1962); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

*Cycadopites grandis* de Jersey and Hamilton, 1967

*Remarks*:—This species is a rare component of the Clematis microflora.

*Distribution*:—Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

*Cycadopites granulatus* (de Jersey) de Jersey, 1964

*Remarks*:—Rare specimens of this species have been observed in the Clematis assemblages.

*Distribution*:—Triassic of Ipswich Coal Measures (de Jersey, 1962); Upper Triassic of Bundamba Group (de Jersey, 1964); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone.

#### MICROFLORAL SEQUENCE IN THE MIMOSA SYNCLINE

The thickest continuous vertical section of the Clematis Sandstone, studied in the present investigation, is that penetrated by D.R.D. 9, on the western side of the Mimosa Syncline. As indicated previously it is in the western limb of this structure that the formation attains its greatest thickness—about 1,000 feet. In D.R.D. 9 the top 500 feet of this section was cored continuously and microfloral assemblages have been studied from 11 samples distributed through this interval. As the basal part of the Moolayember Formation, down to the Moolayember-Clematis boundary (at 411 feet in D.R.D. 9) had been studied previously (de Jersey and Hamilton, 1967) a continuous sequence of assemblages, comprising the upper Clematis and basal Moolayember microfloras, has now been examined. The distribution of genera and species within this sequence is shown diagrammatically in Figure 2.

Study of Figure 2 indicates that assemblages from the upper 500 feet of the Clematis Sandstone are similar in many respects to those from the basal portion of the Moolayember Formation. Thus they are dominated by *Alisporites*; other forms which are present in significant proportions in both Clematis and Moolayember assemblages include *Leiotriletes directus*, *Osmundacidites* and *Stereisporites*. In this microfloral sequence, there are relatively few species, which are confined to part of the succession, or which show significant changes in abundance. This lack of any marked change from upper Clematis to basal Moolayember supports the view that there was continuous sedimentation within the section penetrated by D.R.D. 9. The conformable, gradational contact between the formations in this hole accords with this view.



One of the few species, restricted to portion of the sequence in D.R.D. 9, is *Duplexisporites gyratus*. It was present in two of the assemblages from the basal Moolayember Formation, but absent from all assemblages from the Clematis Sandstone. Unfortunately it is too rare and sporadically distributed in the lower part of its stratigraphic range, for its presence to be used as a sole criterion for distinguishing Moolayember from Clematis assemblages. Its presence, rather than its absence, taken in conjunction with other evidence, may be of some importance in correlation studies. Another species, which appears to have stratigraphic significance within this section, is *Aratrisporites* cf. *rotundus*. Although this species ranges through the entire section, it is relatively rare below the upper part of the Clematis Sandstone. In this formation, assemblages with more than one per cent of this species are confined to the section 200 feet below the Clematis-Moolayember boundary. This species was found to be common in some assemblages from the lower Moolayember Formation (de Jersey and Hamilton, 1967, Figure 2). Its presence in some abundance would thus provide evidence for assigning an assemblage to the lower Moolayember, or uppermost Clematis, portion of the succession.

A species which should also be of value in distinguishing Moolayember from Clematis microfloras is *Cadargasporites senectus*. This species has been recorded from a section in the lower half of the Moolayember Formation (de Jersey and Hamilton, 1967, fig. 2), but has not been observed in any of the Clematis assemblages. Its presence in an assemblage would thus strongly favour correlation with the Moolayember Formation, rather than with the Clematis Sandstone.

On the eastern side of the Mimosa Syncline, the Clematis Sandstone has been sampled by three holes, D.R.D. 2, D.R.D. 4 and D.R.D. 16, which, taken in conjunction, have cored the complete thickness of the formation (about 450 feet in this area). As mentioned previously D.R.D. 2 was drilled from basal Moolayember into Clematis sediments, D.R.D. 4 from lower Clematis Sandstone into the Rewan Formation, while D.R.D. 16 was drilled at an intermediate location, to provide a continuous section from a level equivalent to that of the lower part of D.R.D. 2, down into the Rewan Formation. Assemblages recorded from D.R.D. 16 provide a microfloral sequence representative of microfloras from both D.R.D. 2 and D.R.D. 4. Consequently Figure 3, which illustrates the microfloral sequence in the Clematis Sandstone in this area, is based on assemblages from D.R.D. 16.

Study of Figure 3 indicates that there is a gradual, rather than a sudden, change in composition of the assemblages from uppermost Rewan to basal Clematis sediments. This is in accordance with lithological evidence for a conformable, gradational, boundary

between the formations in this area; thus it seems likely that there was continuous sedimentation in this part of the succession.

In the microfloral sequence illustrated by Figure 3, there is a gradual decline downwards in the proportion of *Alisporites*, associated with a progressive increase in the proportion of *Osmundacidites*. As a result *Alisporites*, which dominates most of the Clematis assemblages, is replaced as the dominant genus by *Osmundacidites* in microfloras from the uppermost Rewan sediments. Regarding the species represented in this diagram, the distribution of *Aratrisporites tenuispinosus* has considerable stratigraphic significance. This is a distinctive species which is persistently present in assemblages from the uppermost Rewan Formation (from D.R.D. 4 and D.R.D. 16). Its range extends into the basal Clematis Sandstone and terminates in the lower part of that formation. It is common (13 per cent) in the basal Clematis assemblage from 351ft. in D.R.D. 16, but absent from the succeeding assemblages from that hole. There is a fairly large gap in the sampling of D.R.D. 16 (between 191ft. and 351ft.) and knowledge of microfloras in this part of the sequence is provided by assemblages from D.R.D. 4. These assemblages show that the upper limit of the range of *A. tenuispinosus* is about 100 feet above the base of the Clematis Sandstone.

In addition to *A. tenuispinosus*, other species similarly range upwards from the Rewan Formation and have ranges which terminate in the lower part of the Clematis Sandstone. These include *Aratrisporites wollariensis*, *Indospora clara*, *Indospora reticulata* and *Striatissaccus novimundi*. As they are much less common than *A. tenuispinosus*, in assemblages where they are present, they are less important stratigraphically. However, their distribution and that of *A. tenuispinosus* are suggestive of the gradual decline and extinction of certain elements of the flora in the changed environment, which accompanied the change from Rewan- to Clematis-type sedimentation.

Comparison of the Clematis assemblages from opposite sides of the Mimosa Syncline reveals differences which are considered to have stratigraphic significance. Species represented in assemblages from holes drilled in the eastern limb of this structure include *Aratrisporites tenuispinosus* (restricted to the basal 100 feet of the formation), *Indospora clara*, *Indospora reticulata* and *Striatissaccus novimundi*. All these species are survivals from assemblages of the underlying Rewan Formation. They are all absent from microfloras, recorded from the upper Clematis Sandstone, on the western side of the Mimosa Syncline. Their absence from the latter section is an indication that the sediments penetrated by D.R.D. 9 are younger than most, if not all of the Clematis Sandstone sampled in the eastern side of the syncline.



It is suggested that this evidence for these differences in age can be correlated with differences in thickness of the formation on opposite sides of the Mimosa Syncline. As the thickness of the Clematis Sandstone on the eastern side of this structure is only about half that on the western side, it seems likely that there is a facies change from east to west, and that sediments of the upper Clematis Sandstone in the west are equivalent in time to strata mapped as basal Moolayember Formation on the eastern side.

An alternative explanation, for these differences between microfloral assemblages on opposite sides of the Mimosa Syncline, is that the differences have resulted from different environments of deposition. It was found, for example, that different assemblages were obtained from samples of different lithology, at similar stratigraphic levels in the Moolayember Formation (de Jersey and Hamilton, 1967, pp. 20, 21). However the Clematis Sandstone appears to have been deposited in a much more uniform environment than the Moolayember sediments; moreover the assemblages recorded do not exhibit such marked variation between themselves, as was the case for some of the Moolayember assemblages. Hence it is considered that the previous suggestion, that the differences in the assemblages are related to their different stratigraphic positions, is a more likely explanation than that based on differences in environment of deposition.

#### COMPARISON WITH OTHER AUSTRALIAN TRIASSIC MICROFLORAS

As the Clematis Sandstone directly underlies the Moolayember Formation, comparison of microfloras of these formations is particularly relevant to study of the microfloral succession in the Triassic of the Bowen Basin. As indicated previously, microfloras of the two formations have many features in common; however there are some species which are restricted to either Clematis, or Moolayember, assemblages. Among these are *Duplexisporites gyratus*, which first appears near the base of the Moolayember Formation, and *Cadargosporites senectus*, which has been recorded only from horizons in the lower part of that formation. Species present in Clematis, but not recorded in Moolayember microfloras, include *Aratrisporites tenuispinosus*, *Aratrisporites wollariensis*, *Indospora clara*, *Indospora reticulata*, *Striatissaccus novimundi* and *Triadispora crassa*. These species characterize assemblages from stratigraphic holes drilled in the eastern limb of the Mimosa Syncline.

As indicated above, these assemblages probably represent horizons in the lower part of the Clematis Sandstone, when the maximum development of the formation is considered. As a result of progressive changes in the microfloras, it can be expected that such

assemblages, from lower horizons in the Clematis Sandstone, will exhibit greater differences from the Moolayember microfloras, than those from higher in the Clematis sequence. In general terms, this means that Moolayember and Clematis assemblages from near the boundary between the formations, are difficult to distinguish; distinction between microfloras from the formations should become progressively easier with increase in the stratigraphic interval between the assemblages concerned.

In Queensland, Triassic microfloras have also been described from the Ipswich Coal Measures and Bundamba Group (de Jersey, 1962, 1964). Evidence, summarized previously (de Jersey and Hamilton, 1967, p. 23), indicates that the Moolayember assemblages are older than those from the Ipswich-Bundamba succession; hence the Clematis Sandstone should also be regarded as significantly older than sediments of the Ipswich-Bundamba sequence. A similar position exists with regard to Upper Triassic microfloras described from Leigh Creek, South Australia by Playford and Dettmann (1965) and from the Brady Formation of Tasmania by Playford (1965). Assemblages from the Clematis Sandstone, like those from the Moolayember Formation, are considered to antedate these late Triassic microfloras.

In New South Wales, Helby (1967) has recently described a microflora from the Wollar Sandstone. This microflora has several species in common with the Clematis assemblages, including *Aratrisporites wollariensis*, *Aratrisporites tenuispinosus*, *Cyathidites breviradiatus* and *Kraeuselisporites differens*. These species are present in the lower part of the Clematis Sandstone and have also been observed in the uppermost Rewan Formation. Final conclusions, regarding correlation of the Wollar Sandstone with the Bowen Basin sequence, cannot be reached until detailed study of the Rewan assemblages has been completed. However, preliminary study indicates that *Aratrisporites wollariensis* is more abundant in assemblages from the uppermost Rewan Formation than in the Clematis microfloras. Thus it is suggested that the Wollar Sandstone is more likely to be equivalent to portion of the upper Rewan Formation, than to the Clematis Sandstone.

Microfloras from the Tiers Formation of Tasmania described by Playford (1965) are also rather similar to those from the Clematis Sandstone. Species common to the two formations include *Aratrisporites strigosus*, *Aratrisporites tenuispinosus*, *Nevesisporites limatulus* and *Tigrisporites playfordi*. Final appraisal of the relationships of these units must await more detailed study of the Tasmanian assemblages, and also completion of the current investigation of microfloras from the Rewan Formation. As *Aratrisporites tenuispinosus*, which ranges through the Tiers Formation, has only been observed in the basal part of the Clematis Sand-



stone, it may perhaps be suggested that the Tiers Formation should be correlated with the uppermost Rewan Formation, rather than with the Clematis Sandstone.

Finally, the Clematis assemblages, like those of the Moolayember Formation, are of distinctly younger aspect than Lower Triassic microfloras described from the Kockatea Shale of Western Australia (Balme, 1963) and Ross Formation of Tasmania (Playford, 1965). These Lower Triassic microfloras are characterized by the presence of *Lundbladispore brevicula*, *Lundbladispore willmotti* and *Kraeuselisporites cuspidus*, associated with abundant striate bisaccate pollens. These species are missing from the Clematis assemblages, which also contain many species not present in these Lower Triassic microfloras. An assemblage from Permo-Triassic transition beds in the Sydney Basin, described by Hennelly (1958) is of even earlier aspect, as it antedates the appearance of *Lundbladispore* (Evans, 1966, p. 59). Thus this assemblage is separated by an appreciable time interval from the Clematis microfloras, with which it has little in common.

#### AGE OF THE CLEMATIS SANDSTONE

Evidence for assigning the Moolayember Formation to the Middle Triassic has been summarized previously (de Jersey and Hamilton, 1967, p. 24). In view of the conformable relationship of the formations, a Lower or Middle Triassic age is indicated for the underlying Clematis Sandstone. A more precise estimate of the age of the Clematis sediments can be obtained by study of the relationship of the Queensland assemblages to the Triassic microfloral succession in Europe. In recent years, knowledge of the latter has improved considerably, as a result of the publication of several important descriptive and biostratigraphic papers. Thus, at the present time, the European microfloral sequence is sufficiently well known to provide a basis for comparison with Australian microfloras, at least with reference to the major divisions of Triassic time.

Such a comparison is particularly relevant for the Clematis assemblages, because of the presence in them of several European species. Among these is *Accinctisporites ligatus*, which first appears at the base of the Muschelkalk in Europe (Schulz, 1966, Table 5b); its presence in the lower part of the Clematis Sandstone would accordingly favour a Middle, rather than a Lower, Triassic age for the formation.

Additional evidence on the age of the Clematis assemblages has been provided by the discovery in

them of three distinctive species—*Triadispora crassa*, *T. falcata*, and *Voltziaceasporites heteromorpha*. The presence of these species is regarded as possibly more significant than the occurrence of *A. ligatus*, because they are more widely distributed in the European microfloras. These three species make their first appearance in the late Lower Triassic (Klaus, 1964, 1965; Schulz, 1966; Visscher, 1966). Although all of them, range upwards into the Muschelkalk, they are particularly characteristic of the uppermost Bunter Sandstone (the Röt of Germany and the Netherlands). Consequently their presence in the Clematis assemblages would indicate an age not earlier than late Scythian (late Lower Triassic). As assemblages from the overlying Moolayember Formation, up to 6,000 feet in thickness, are all of Middle Triassic aspect, a late Scythian or early Anisian age is accordingly indicated for the Clematis Sandstone.

More precise correlation with the standard European succession must await detailed study of assemblages from the Rewan Formation, which should enable the lower limits of the ranges of distinctive species, such as *T. crassa* and *V. heteromorpha*, to be determined. It is clear, however, from data now available, that there are promising prospects for intercontinental correlation of Triassic sediments, on microfloral evidence, and that palynological studies should eventually lead to accurate dating of many Triassic formations of continental origin, such as the Clematis Sandstone.

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PLATE I

(All photographs approximately X1000, unless otherwise stated)

Figure 1 —*Concavisporites tumidus* Playford (proximal focus)

Figure 2 —*Cyathidites breviradiatus* Helby

Figure 3 —*Calamospora tener* (Leschik) de Jersey

Figure 4 —*Dictyophyllidites harrisii* Couper

Figure 5 —*Dictyophyllidites mortoni* (de Jersey) Playford and Dettmann

Figure 6 —*Stereisporites antiquasporites* (Wilson and Webster) Dettmann

Figure 7 —*Clavatriletes* sp. cf. *C. hammenii* Herbst (x630)

Figure 8 —*Guttatisporites visscheri*, sp. nov. (distal focus)

Figure 9 —*Converrucosisporites cameroni* (de Jersey) Playford and Dettmann

Figure 10—*Guttatisporites visscheri* sp. nov. (Holotype, proximal focus)

Figure 11—*Guttatisporites visscheri* sp. nov. (Holotype, distal focus)

Figure 12—*Apiculatisporis clematissi* sp. nov. (Holotype, equatorial focus)



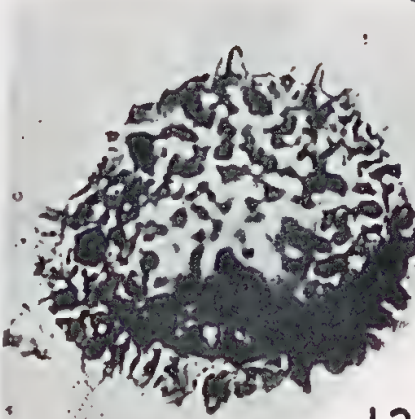
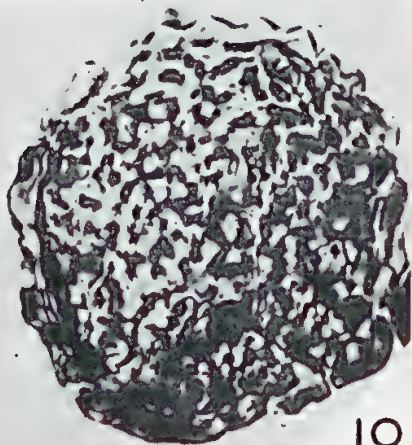
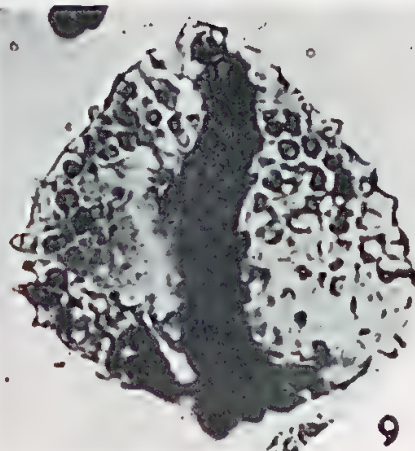
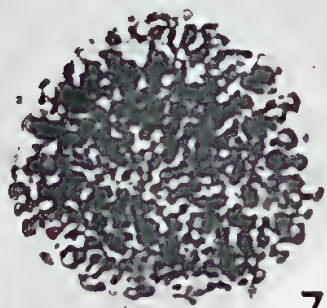
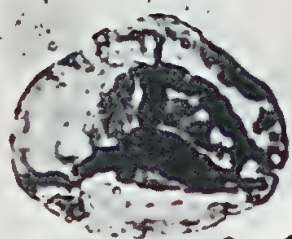
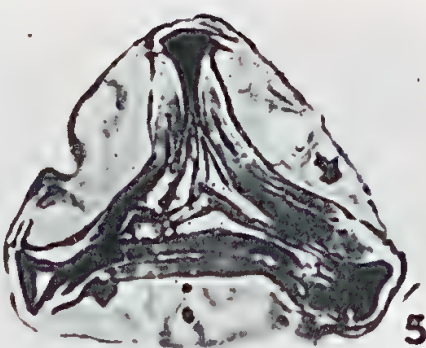
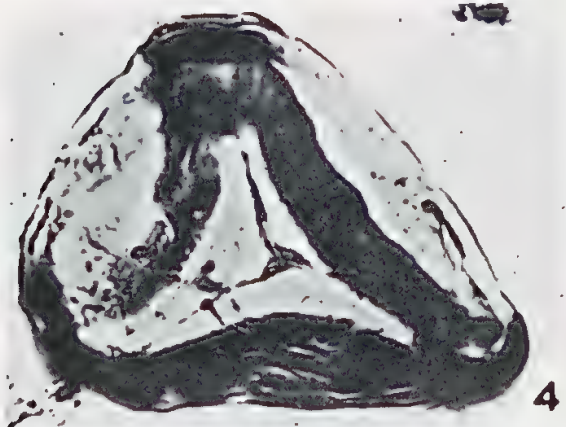
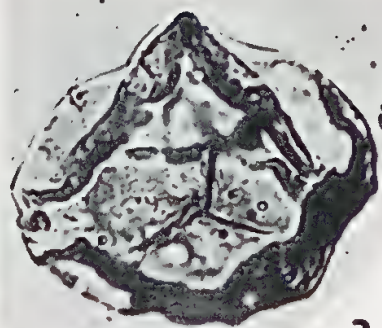
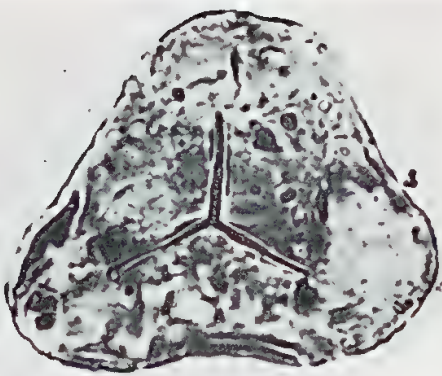
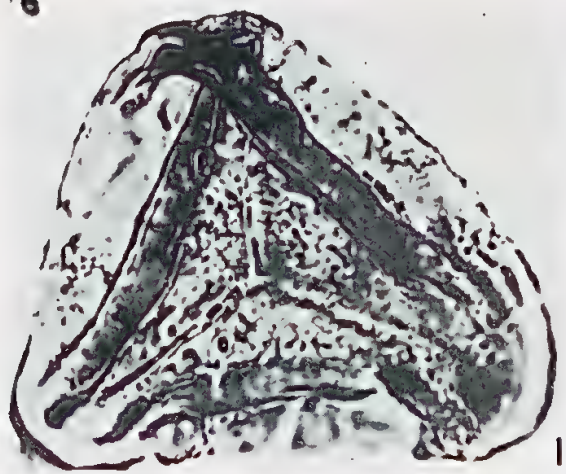


PLATE 1



PLATE 2

(All photographs approximately X1000)

- Figure 1 —*Indospora reticulata*, sp. nov. (distal focus)  
Figure 2 —*Indospora reticulata*, sp. nov. (equatorial focus)  
Figure 3 —*Lophotriletes bauhiniae* de Jersey and Hamilton  
Figure 4 —*Indospora reticulata*, sp. nov. (Holotype, distal focus)  
Figure 5 —*Indospora reticulata*, sp. nov. (Holotype, equatorial focus)  
Figure 6 —*Equisetoporites steevesi* (Jansonius) comb. nov.  
Figure 7 —*Equisetoporites steevesi* (Jansonius) comb. nov.  
Figure 8 —*Indospora clara* Bharadwaj  
Figure 9 —*Indospora clara* Bharadwaj  
Figure 10—*Cycadopites nitidus* (Balme) de Jersey



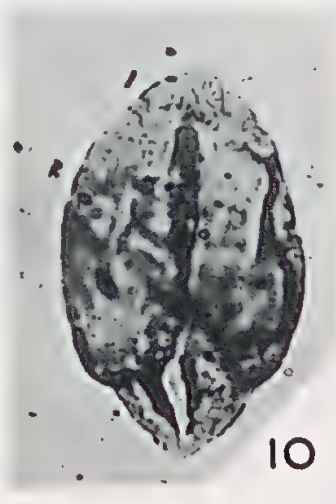
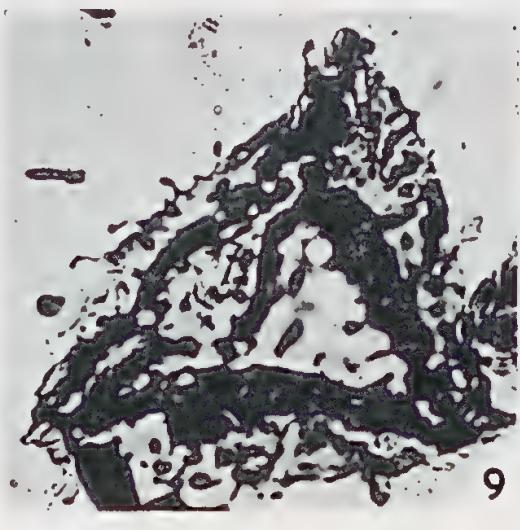
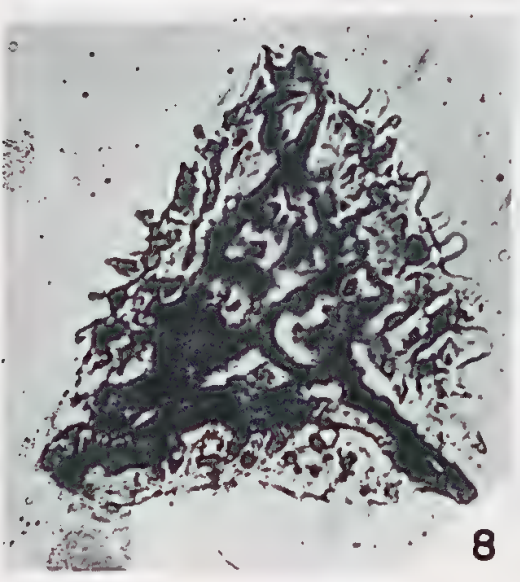
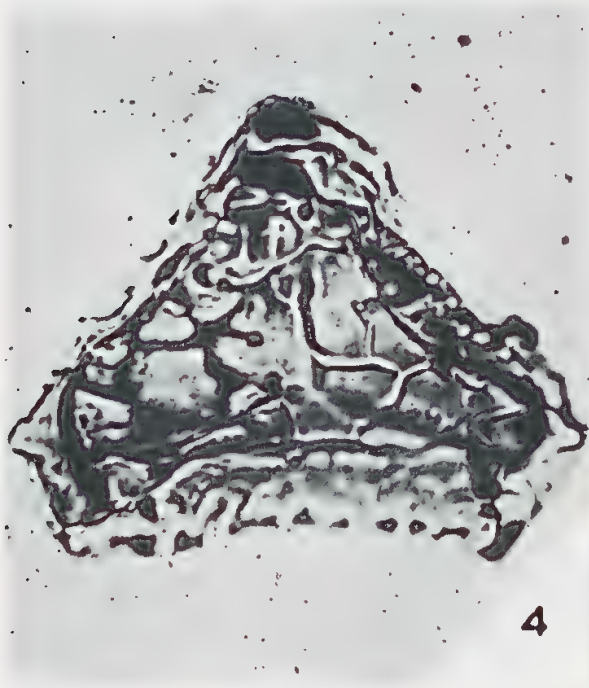
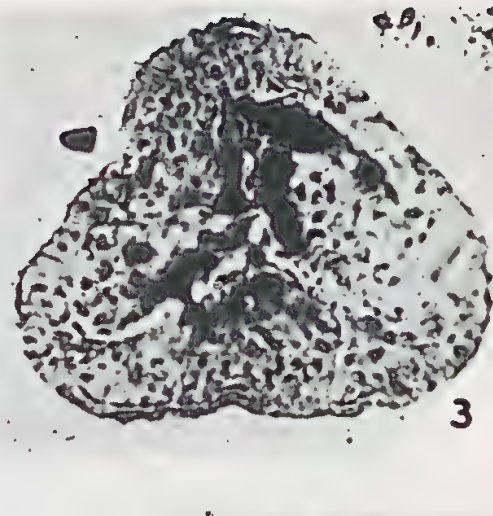
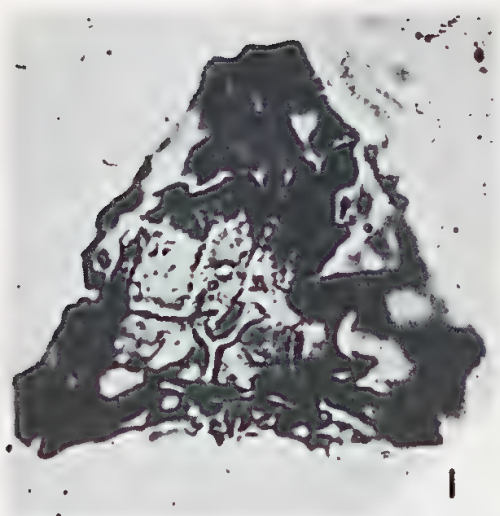


PLATE 2



PLATE 3

(All photographs approximately X1000, unless otherwise stated)

- Figure 1 —*Krauselisporites differens* Helby (x630)  
Figure 2 —*Nevesisporites limatulus* Playford (Proximal focus)  
Figure 3 —*Guthoerlisporites cancellosus* Playford and Dettmann (x630)  
Figure 4 —*Accinctisporites ligatus* Leschik (x630—proximal focus)  
Figure 5 —*Stenozonotriletes* sp.  
Figure 6 —*Accinctisporites ligatus* Leschik (x630—median focus, intexine missing).  
Figure 7 —*Alisporites townrovi* Helby (Distal focus)  
Figure 8 —*Alisporites australis* de Jersey (Distal focus)  
Figure 9 —*Limitisporites* sp. (x630—proximal focus)  
Figure 10—*Platysaccus queenslandi* de Jersey (x630—median focus)



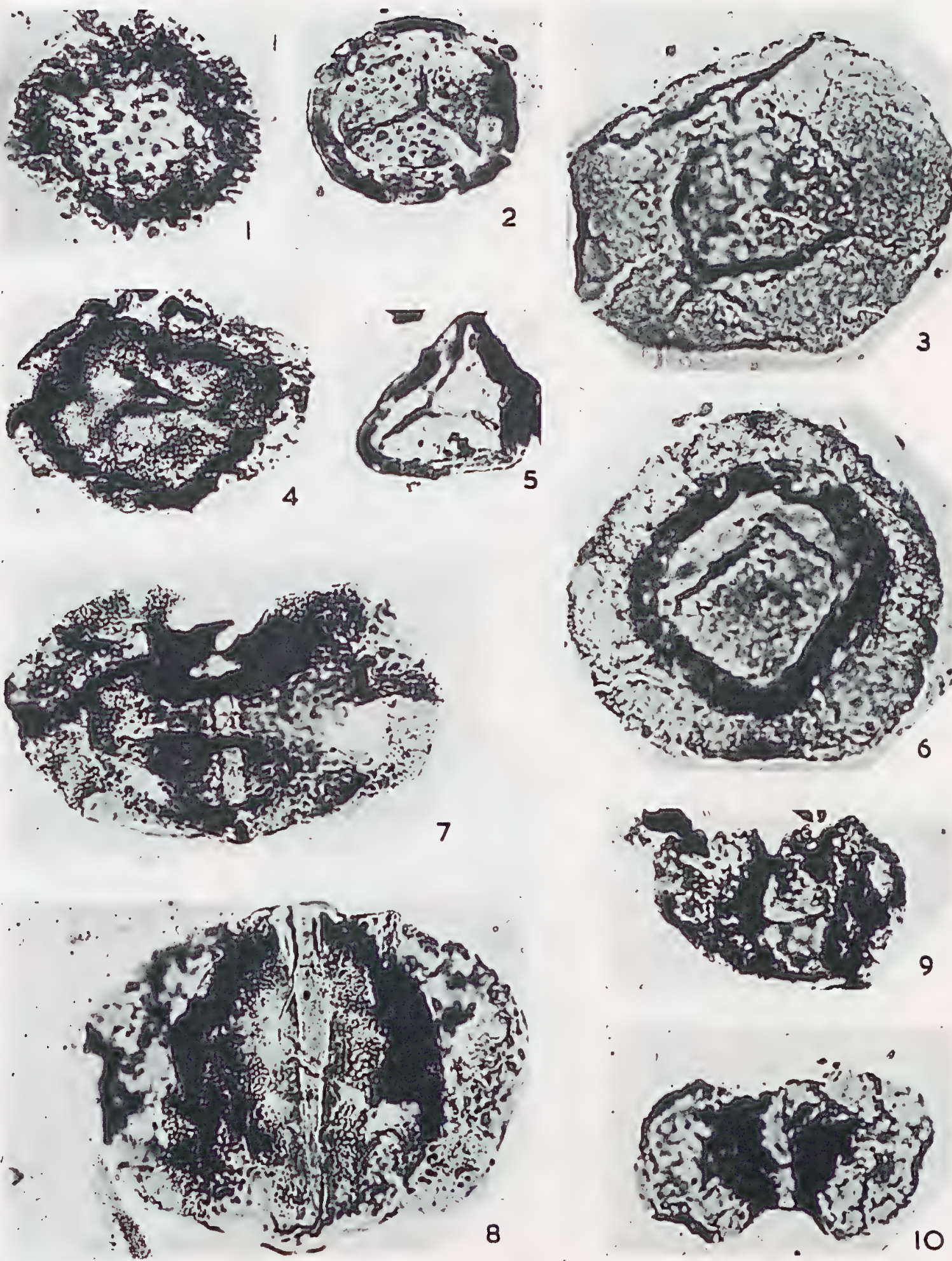


PLATE 3



PLATE 4

(All photographs approximately X1000, unless otherwise stated)

Figure 1 —*Chordasporites australiensis* de Jersey (Proximal focus)

Figure 2 —*Triadispora falcata* Klaus

Figure 3 —*Chordasporites australiensis* de Jersey (Distal focus)

Figure 4 —*Triadispora* sp. cf. *T. muelleri* (Reinhardt and Schmitz)  
Visscher

Figure 5 —*Grebespora concentrica* Jansonius

Figure 6 —*Sulcatisporites* sp. cf. *S. krauseli* Mädlar

Figure 7 —*Triadispora crassa* Klaus (x630—oblique equatorial  
view)

Figure 8 —*Sulcosaccispora alaticonformis* (Malyavkina), comb.  
nov.

Figure 9 —*Vitreisporites microsaccus* de Jersey

Figure 10—*Vitreisporites pallidus* (Reissinger) Nilsson



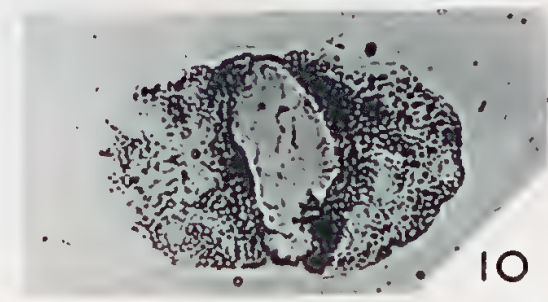
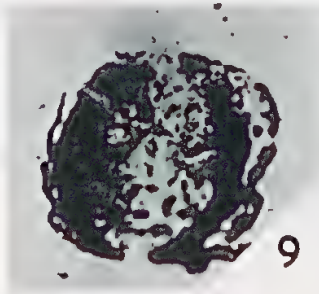
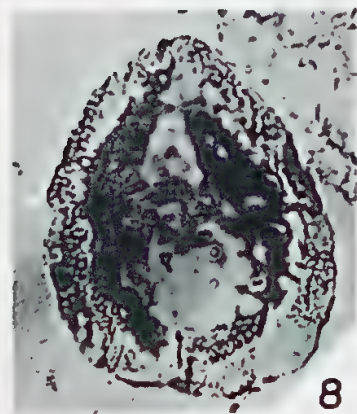
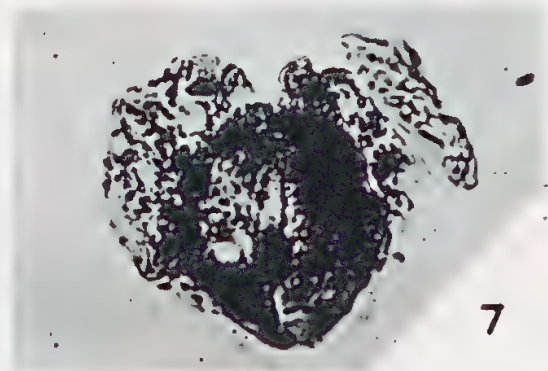
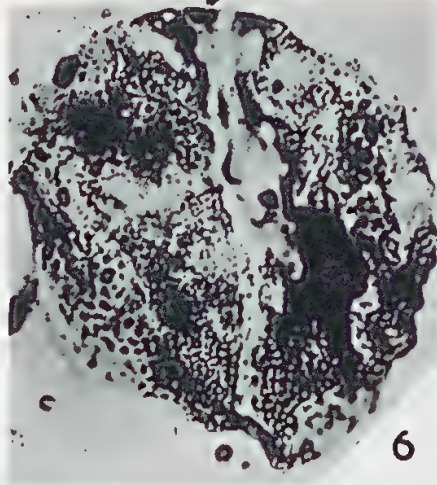
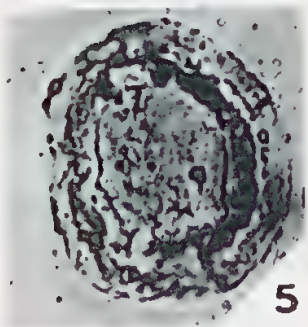
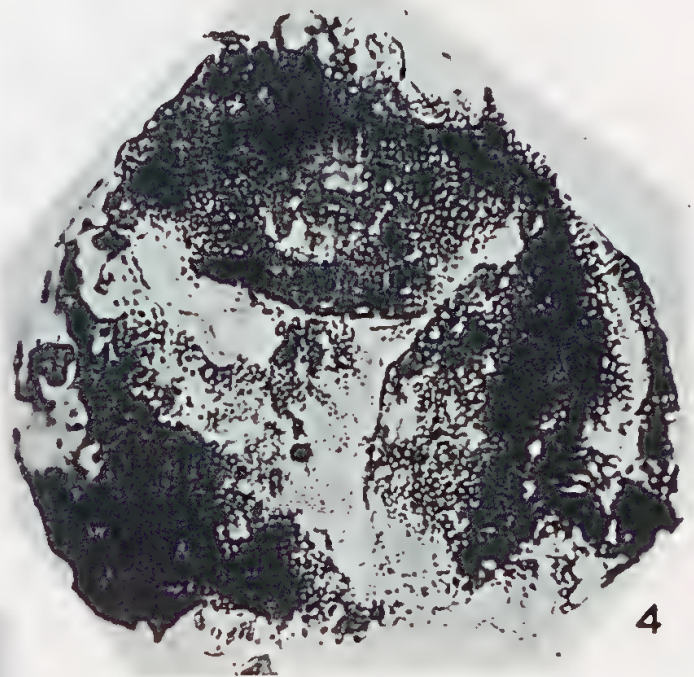
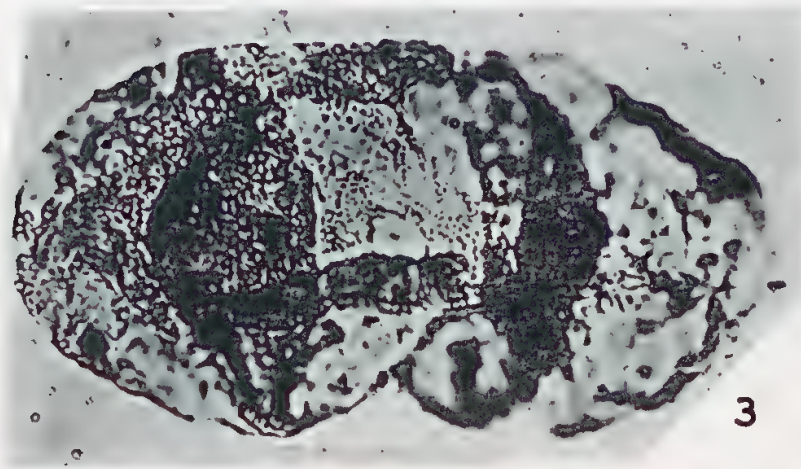
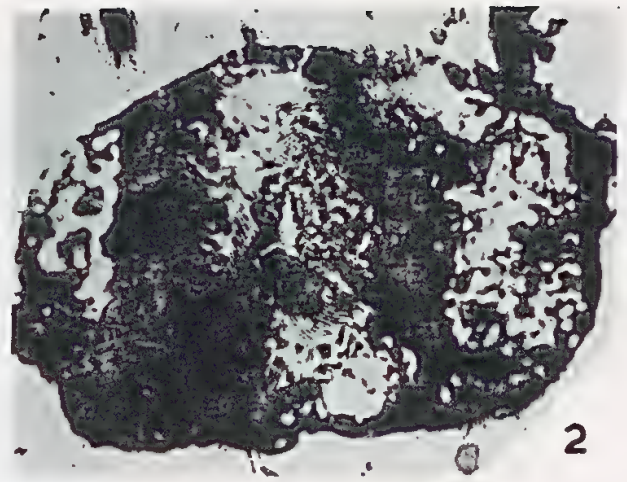
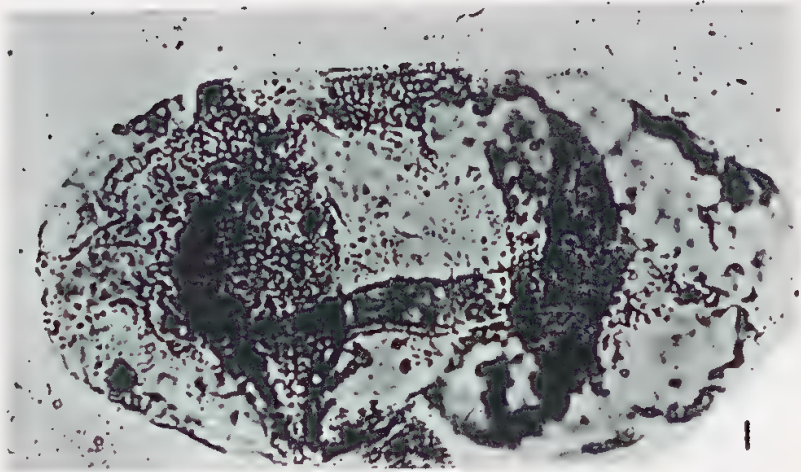


PLATE 4



PLATE 5

(All photographs approximately X1000)

- Figure 1 —*Voltziaceasporites heteromorpha* Klaus  
Figure 2 —*Hamiapollenites insculptus* Playford and Dettmann  
Figure 3 —*Striatissaccus novimundi* (Jansonius), comb. nov.  
Figure 4 —cf. *Tubantiapollenites striatitoides* Visscher  
Figure 5 —*Aratrisporites wollariensis* Helby  
Figure 6 —*Aratrisporites* sp. A  
Figure 7 —*Aratrisporites plicatus* de Jersey and Hamilton  
Figure 8 —*Aratrisporites* sp. cf. *A. rotundus* Mädler  
Figure 9 —*Aratrisporites tenuispinosus* Playford



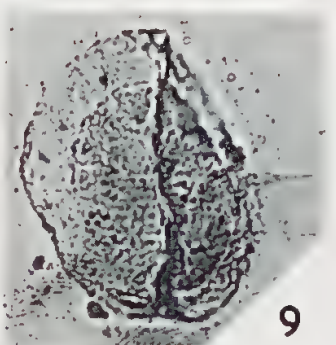
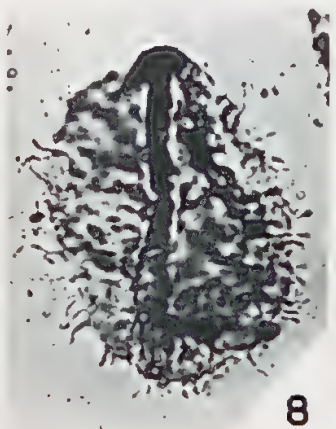
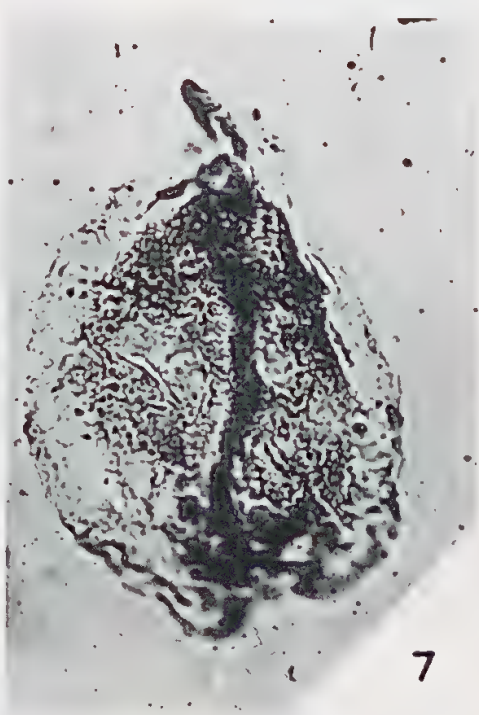
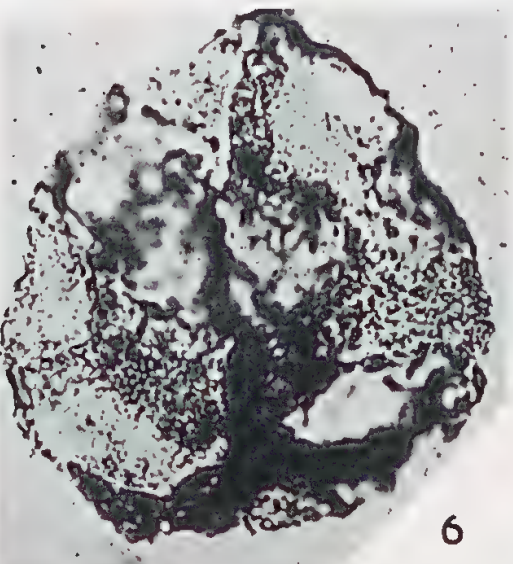
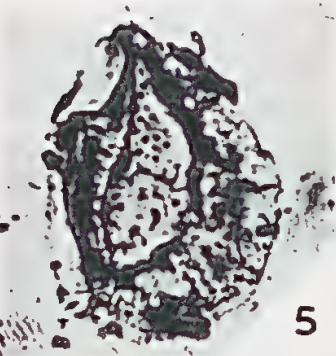
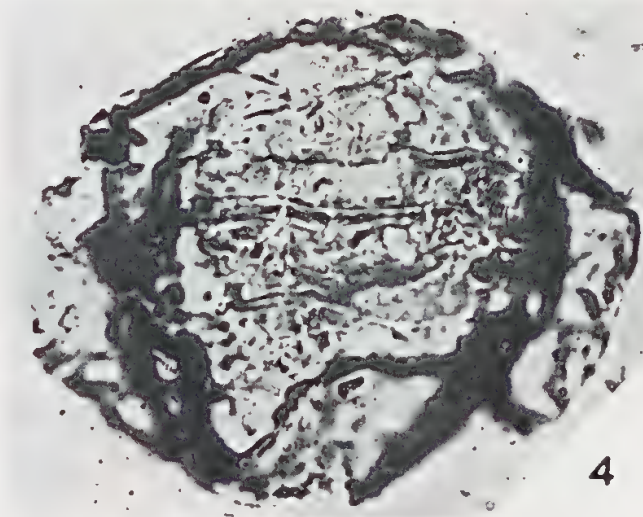
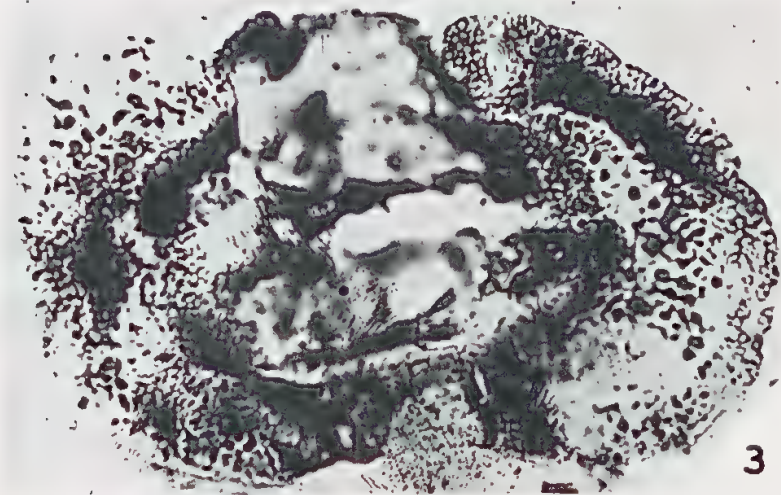
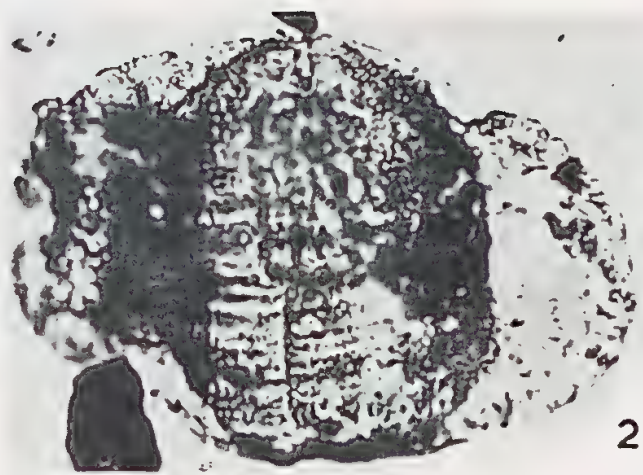


PLATE 5



## APPENDIX—Lists of Microfloral Assemblages

The assemblages recorded below are arranged in ascending stratigraphic order for each of the stratigraphic drillholes. In the heading for each sample, depth, lithology and number of specimens examined are recorded. Regarding the latter, the figures indicate that counts of these magnitudes were made; addition of the + sign, e.g. 200+, indicates that an additional low power traverse was made of each of the available slides. Species recorded only in such additional traverses are indicated by the sign + in each list. Indeterminate specimens have not been included.

## D.R.D. No. 16

## 351ft.

Grey shale

Count 200+

|                                               |       |
|-----------------------------------------------|-------|
| <i>Accinctisporites ligatus</i>               | +     |
| <i>Alisporites</i> spp.                       | 26.5% |
| <i>Apiculatisporis</i> spp.                   | 1.5%  |
| <i>Aratrisporites plicatus</i>                | 0.5%  |
| <i>Aratrisporites</i> cf. <i>rotundus</i>     | 1.0%  |
| <i>Aratrisporites strigosus</i>               | 0.5%  |
| <i>Aratrisporites tenuispinosus</i>           | 13.0% |
| <i>Aratrisporites wollariensis</i>            | +     |
| <i>Aratrisporites</i> sp. (indet.)            | 1.5%  |
| <i>Araucariacites</i> sp.                     | 1.0%  |
| <i>Converrucosisporites cameroni</i>          | +     |
| <i>Converrucosisporites</i> sp. (indet.)      | 0.5%  |
| <i>Convolutispora</i> sp.                     | 0.5%  |
| <i>Cyathidites breviradiatus</i>              | +     |
| <i>Cycadopites</i> cf. <i>grandis</i>         | +     |
| <i>Cycadopites nitidus</i>                    | 1.0%  |
| <i>Dictyophyllidites mortoni</i>              | +     |
| <i>Dictyophyllidites</i> sp. (indet.)         | 0.5%  |
| <i>Foveosporites</i> sp.                      | 0.5%  |
| <i>Granulatisporites</i> spp.                 | 4.5%  |
| <i>Hamiapollenites insculptus</i>             | +     |
| <i>Inaperturopollenites</i> sp.               | 2.0%  |
| <i>Indospora clara</i>                        | +     |
| <i>Indospora reticulata</i>                   | +     |
| <i>Leiotriletes directus</i>                  | 5.0%  |
| <i>Osmundacidites</i> spp.                    | 34.5% |
| <i>Parasaccites</i> sp.                       | +     |
| <i>Platysaccus queenslandi</i>                | 1.0%  |
| <i>Punctatisporites</i> sp.                   | 0.5%  |
| <i>Rugulatisporites</i> sp.                   | 0.5%  |
| <i>Stereisporites</i> sp.                     | 0.5%  |
| <i>Striatissaccus novimundi</i>               | 0.5%  |
| <i>Triadispora crassa</i>                     | +     |
| <i>Triadispora</i> sp. cf. <i>T. muelleri</i> | +     |
| <i>Verrucosisporites</i> spp.                 | 2.0%  |
| <i>Voltziaceasporites heteromorpha</i>        | +     |
| Striate bisaccate pollen (indet.)             | 0.5%  |

## 191ft.

Grey shale

Count 200+

|                                                 |       |
|-------------------------------------------------|-------|
| <i>Acanthotriletes</i> sp.                      | 0.5%  |
| <i>Accinctisporites ligatus</i>                 | +     |
| <i>Accinctisporites</i> sp.                     | 0.5%  |
| <i>Alisporites</i> spp.                         | 25.5% |
| <i>Apiculatisporis</i> spp.                     | 9.0%  |
| <i>Aratrisporites plicatus</i>                  | 2.0%  |
| <i>Aratrisporites</i> cf. <i>rotundus</i>       | 0.5%  |
| <i>Aratrisporites strigosus</i>                 | 1.5%  |
| <i>Aratrisporites wollariensis</i>              | 0.5%  |
| <i>Aratrisporites</i> sp. (indet.)              | 1.0%  |
| <i>Araucariacites</i> spp.                      | 2.0%  |
| <i>Calamospora</i> sp.                          | 0.5%  |
| <i>Chordasporites australiensis</i>             | 0.5%  |
| <i>Converrucosisporites</i> cf. <i>cameroni</i> | 0.5%  |
| <i>Converrucosisporites</i> spp. (indet.)       | 4.5%  |
| <i>Convolutispora</i> sp.                       | 0.5%  |

|                                             |       |
|---------------------------------------------|-------|
| <i>Cyathidites breviradiatus</i>            | 1.0%  |
| <i>Cycadopites granulatus</i>               | 1.0%  |
| <i>Cycadopites nitidus</i>                  | 1.5%  |
| <i>Cycadopites</i> sp. (indet.)             | 1.0%  |
| <i>Dictyophyllidites harrisii</i>           | +     |
| <i>Dictyophyllidites mortoni</i>            | 0.5%  |
| <i>Granulatisporites</i> spp.               | 7.5%  |
| <i>Grebespora concentrica</i>               | +     |
| <i>Hamiapollenites insculptus</i>           | 0.5%  |
| <i>Inaperturopollenites</i> spp.            | 1.5%  |
| <i>Indospora reticulata</i>                 | +     |
| <i>Kraeuselisporites differens</i>          | +     |
| <i>Kraeuselisporites</i> sp. (indet.)       | +     |
| <i>Leiotriletes directus</i>                | 8.0%  |
| <i>Lophotriletes baubini</i>                | +     |
| <i>Lophotriletes</i> spp. (indet.)          | 3.5%  |
| <i>Osmundacidites</i> spp.                  | 14.0% |
| <i>Platysaccus queenslandi</i>              | +     |
| <i>Platysaccus</i> cf. <i>queenslandi</i>   | 0.5%  |
| <i>Polypodiisporites ipsviciensis</i>       | 1.0%  |
| <i>Punctatisporites</i> spp.                | 1.5%  |
| <i>Retusotriletes</i> sp.                   | +     |
| <i>Rugulatisporites</i> cf. <i>trisinus</i> | 0.5%  |
| <i>Rugulatisporites</i> sp. (indet.)        | 1.0%  |
| <i>Stereisporites</i> spp.                  | 3.5%  |
| <i>Sulcosaccispora alaticonformis</i>       | +     |
| <i>Tigrisporites playfordi</i>              | +     |
| cf. <i>Tubantiapollenites striatitoides</i> | +     |
| <i>Verrucosisporites</i> spp.               | 2.0%  |
| <i>Vitreisporites pallidus</i>              | +     |
| <i>Voltziaceasporites heteromorpha</i>      | +     |
| Striate bisaccate pollen (indet.)           | 0.5%  |

## 175ft. 2in.

Grey mudstone

Count 200+

|                                           |       |
|-------------------------------------------|-------|
| <i>Alisporites</i> spp.                   | 31.5% |
| <i>Apiculatisporis</i> spp.               | 4.0%  |
| <i>Aratrisporites plicatus</i>            | +     |
| <i>Aratrisporites</i> cf. <i>rotundus</i> | +     |
| <i>Calamospora</i> sp.                    | 0.5%  |
| <i>Converrucosisporites cameroni</i>      | 3.5%  |
| <i>Converrucosisporites</i> spp. (indet.) | 5.5%  |
| cf. <i>Converrucosisporites</i> sp.       | +     |
| <i>Cyathidites breviradiatus</i>          | +     |
| <i>Cycadopites nitidus</i>                | 2.5%  |
| <i>Cycadopites</i> sp. (indet.)           | 1.0%  |
| <i>Dictyophyllidites mortoni</i>          | 2.5%  |
| <i>Dictyophyllidites</i> sp. (indet.)     | 0.5%  |
| <i>Granulatisporites</i> spp.             | 3.5%  |
| <i>Guttatisporites visscheri</i>          | 1.0%  |
| <i>Hamiapollenites insculptus</i>         | +     |
| <i>Inaperturopollenites</i> spp.          | 4.5%  |
| <i>Indospora clara</i>                    | +     |
| <i>Leiotriletes directus</i>              | 10.0% |
| <i>Leiotriletes</i> sp. (indet.)          | 1.0%  |
| <i>Lophotriletes</i> sp.                  | 0.5%  |
| <i>Osmundacidites</i> spp.                | 19.0% |
| <i>Polypodiisporites ipsviciensis</i>     | 0.5%  |
| <i>Punctatisporites</i> spp.              | 2.0%  |
| <i>Stereisporites</i> spp.                | 4.5%  |
| <i>Verrucosisporites</i> spp.             | 1.0%  |
| <i>Vitreisporites microsaccus</i>         | 1.0%  |

## 136ft. 6in.

Grey shale

Count 200+

|                                      |       |
|--------------------------------------|-------|
| <i>Acanthotriletes</i> sp.           | 0.5%  |
| <i>Alisporites</i> spp.              | 58.5% |
| <i>Apiculatisporis clematisi</i>     | 0.5%  |
| <i>Apiculatisporis</i> spp. (indet.) | 4.5%  |
| <i>Aratrisporites plicatus</i>       | +     |
| <i>Araucariacites</i> spp.           | 1.5%  |
| cf. <i>Biretisporites</i> sp.        | 0.5%  |



|                                           |       |
|-------------------------------------------|-------|
| <i>Calamospora</i> sp.                    | 0.5%  |
| <i>Chordasporites australiensis</i>       | +     |
| <i>Concavisporites</i> cf. <i>tumidus</i> | +     |
| <i>Converrucosisporites cameroni</i>      | 1.0%  |
| <i>Converrucosisporites</i> sp. (indet.)  | 0.5%  |
| <i>Cycadopites nitidus</i>                | 1.0%  |
| <i>Dictyophyllidites mortoni</i>          | 1.5%  |
| <i>Foveosporites</i> sp.                  | 0.5%  |
| <i>Granulatisporites</i> spp.             | 1.5%  |
| <i>Grebespora concentrica</i>             | +     |
| <i>Hamiapollenites insculptus</i>         | +     |
| <i>Inaperturopollenites</i> sp.           | 0.5%  |
| <i>Indospora clara</i>                    | +     |
| <i>Leiotriletes directus</i>              | 7.5%  |
| <i>Lophotriletes bauhiniae</i>            | +     |
| <i>Lophotriletes</i> sp. (indet.)         | 1.0%  |
| <i>Osmundacidites</i> spp.                | 12.5% |
| <i>Polypodiisporites ipsviciensis</i>     | 0.5%  |
| <i>Punctatisporites</i> sp.               | 0.5%  |
| <i>Stereisporites</i> spp.                | 2.5%  |
| <i>Striatissaccus novimundi</i>           | +     |
| <i>Tigrisporites playfordi</i>            | 0.5%  |
| <i>Verrucosisporites</i> spp.             | 1.0%  |
| <i>Voltziaceasporites heteromorpha</i>    | 0.5%  |

100ft.

Grey shale

Count 200+

|                                                 |       |
|-------------------------------------------------|-------|
| <i>Acanthotriletes</i> sp.                      | +     |
| <i>Accinctisporites ligatus</i>                 | +     |
| <i>Alisporites</i> spp.                         | 47.0% |
| <i>Alisporites australis</i>                    | +     |
| <i>Apiculatisporis clematidis</i>               | +     |
| <i>Apiculatisporis</i> spp.                     | 2.5%  |
| <i>Aratrisporites plicatus</i>                  | +     |
| <i>Aratrisporites strigosus</i>                 | +     |
| <i>Calamospora</i> sp.                          | 0.5%  |
| <i>Converrucosisporites cameroni</i>            | 0.5%  |
| <i>Converrucosisporites</i> cf. <i>cameroni</i> | 0.5%  |
| <i>Converrucosisporites</i> spp. (indet.)       | 2.0%  |
| <i>Convolutispora</i> sp.                       | 1.5%  |
| <i>Cyathidites breviradiatus</i>                | 0.5%  |
| <i>Cyathidites</i> sp. (indet.)                 | 0.5%  |
| <i>Cycadopites nitidus</i>                      | 1.5%  |
| <i>Cycadopites</i> sp.                          | 0.5%  |
| <i>Dictyophyllidites mortoni</i>                | 1.5%  |
| cf. <i>Dictyophyllidites</i> sp.                | 0.5%  |
| cf. <i>Equisetosporites</i> sp.                 | 0.5%  |
| <i>Granulatisporites</i> spp.                   | 2.0%  |
| <i>Guthoerlisporites cancellosus</i>            | 0.5%  |
| <i>Hamiapollenites insculptus</i>               | 0.5%  |
| <i>Inaperturopollenites</i> spp.                | 3.5%  |
| <i>Indospora clara</i>                          | +     |
| <i>Leiotriletes directus</i>                    | 10.5% |
| <i>Leiotriletes</i> sp. (indet.)                | 1.0%  |
| <i>Lophotriletes bauhiniae</i>                  | 1.0%  |
| <i>Lophotriletes</i> spp. (indet.)              | 1.5%  |
| <i>Nevesisporites limatulus</i>                 | +     |
| <i>Osmundacidites</i> spp.                      | 10.5% |
| <i>Platysaccus queenslandi</i>                  | 0.5%  |
| <i>Polypodiisporites ipsviciensis</i>           | 0.5%  |
| <i>Punctatisporites</i> spp.                    | 1.0%  |
| <i>Retusotriletes</i> sp.                       | +     |
| <i>Rugulatisporites</i> spp.                    | 0.5%  |
| <i>Stenozonotriletes</i> sp.                    | +     |
| <i>Stereisporites</i> spp.                      | 2.0%  |
| <i>Striatissaccus novimundi</i>                 | 0.5%  |
| <i>Tigrisporites</i> sp.                        | +     |
| <i>Tuberculatisporites</i> sp.                  | 0.5%  |
| <i>Verrucosisporites</i> spp.                   | 1.5%  |
| <i>Vitreisporites microsaccus</i>               | +     |
| <i>Vitreisporites</i> cf. <i>microsaccus</i>    | 0.5%  |
| Striate bisaccate pollen (indet.)               | 0.5%  |

88ft. 2in.

Grey Shale

Count 200+

|                                        |       |
|----------------------------------------|-------|
| <i>Acanthotriletes</i> spp.            | 1.5%  |
| <i>Alisporites</i> spp.                | 46.0% |
| <i>Apiculatisporis clematidis</i>      | +     |
| <i>Apiculatisporis</i> spp. (indet.)   | 5.0%  |
| <i>Araucariacites</i> sp.              | 0.5%  |
| <i>Chordasporites australiensis</i>    | 0.5%  |
| <i>Converrucosisporites</i> spp.       | 2.5%  |
| <i>Cycadopites nitidus</i>             | 1.5%  |
| <i>Cycadopites</i> sp. (indet.)        | 1.0%  |
| <i>Grebespora concentrica</i>          | +     |
| <i>Dictyophyllidites mortoni</i>       | 1.0%  |
| <i>Equisetosporites</i> sp.            | 0.5%  |
| <i>Granulatisporites</i> spp.          | 3.5%  |
| <i>Guthoerlisporites cancellosus</i>   | +     |
| <i>Hamiapollenites insculptus</i>      | +     |
| <i>Indospora reticulata</i>            | +     |
| <i>Inaperturopollenites</i> spp.       | 1.0%  |
| cf. <i>Densoisporites</i> sp.          | +     |
| <i>Leiotriletes directus</i>           | 7.5%  |
| <i>Lophotriletes bauhiniae</i>         | +     |
| <i>Lophotriletes</i> spp. (indet.)     | 5.0%  |
| cf. <i>Lophotriletes</i> sp.           | 0.5%  |
| <i>Neoraistrickia</i> sp.              | +     |
| <i>Osmundacidites</i> spp.             | 15.0% |
| <i>Platysaccus queenslandi</i>         | +     |
| <i>Punctatisporites</i> sp.            | 0.5%  |
| <i>Stereisporites</i> spp.             | 1.5%  |
| <i>Sulcosaccispora alaticonformis</i>  | +     |
| <i>Tigrisporites playfordi</i>         | 0.5%  |
| <i>Triadispora crassa</i>              | +     |
| <i>Verrucosisporites</i> spp.          | 4.5%  |
| <i>Voltziaceasporites heteromorpha</i> | 0.5%  |

69ft. 9in.

Grey shale

Count 200+

|                                            |       |
|--------------------------------------------|-------|
| <i>Acanthotriletes</i> sp.                 | 0.5%  |
| <i>Accinctisporites ligatus</i>            | +     |
| <i>Alisporites</i> spp.                    | 41.0% |
| <i>Apiculatisporis clematidis</i>          | 1.5%  |
| <i>Apiculatisporis</i> spp. (indet.)       | 3.5%  |
| <i>Aratrisporites plicatus</i>             | +     |
| <i>Aratrisporites</i> cf. <i>rotundus</i>  | 0.5%  |
| <i>Aratrisporites</i> sp. A                | +     |
| <i>Aratrisporites</i> sp. (indet.)         | 0.5%  |
| <i>Calamospora</i> cf. <i>impexa</i>       | 0.5%  |
| <i>Conosmundasporites</i> sp.              | 0.5%  |
| <i>Converrucosisporites cameroni</i>       | +     |
| <i>Converrucosisporites</i> sp. (indet.)   | 5.0%  |
| <i>Cycadopites nitidus</i>                 | 1.5%  |
| <i>Densoisporites</i> cf. <i>playfordi</i> | +     |
| <i>Dictyophyllidites mortoni</i>           | 0.5%  |
| <i>Equisetosporites steevesi</i>           | +     |
| <i>Equisetosporites</i> sp.                | 0.5%  |
| cf. <i>Equisetosporites</i> sp.            | 0.5%  |
| <i>Granulatisporites</i> spp.              | 5.5%  |
| <i>Inaperturopollenites</i> spp.           | 2.0%  |
| <i>Indospora clara</i>                     | 0.5%  |
| <i>Indospora reticulata</i>                | +     |
| <i>Leiotriletes directus</i>               | 2.5%  |
| <i>Lophotriletes</i> spp.                  | 2.0%  |
| cf. <i>Lophotriletes</i> sp.               | 0.5%  |
| <i>Osmundacidites</i> spp.                 | 21.0% |
| <i>Parasaccites</i> sp.                    | +     |
| <i>Platysaccus queenslandi</i>             | 1.0%  |
| <i>Platysaccus</i> spp. (indet.)           | 1.0%  |
| <i>Punctatisporites</i> spp.               | 1.0%  |
| <i>Stereisporites</i> spp.                 | 1.0%  |
| <i>Striatissaccus</i> sp.                  | 0.5%  |
| <i>Tigrisporites playfordi</i>             | +     |
| <i>Verrucosisporites</i> spp.              | 4.0%  |
| <i>Vitreisporites microsaccus</i>          | +     |
| <i>Vitreisporites pallidus</i>             | 0.5%  |



## 32ft. 6in.

| Grey shale                                      | Count 200+ |
|-------------------------------------------------|------------|
| <i>Alisporites</i> spp.                         | 55.0%      |
| <i>Alisporites</i> cf. <i>microreticulatus</i>  | +          |
| <i>Apiculatisporis</i> spp.                     | 3.5%       |
| <i>Aratrisporites plicatus</i>                  | +          |
| <i>Araucariacites</i> spp.                      | 1.0%       |
| cf. <i>Araucariacites</i> sp.                   | +          |
| <i>Converrucosisporites</i> cf. <i>cameroni</i> | +          |
| <i>Cyathidites breviradiatus</i>                | +          |
| <i>Cycadopites nitidus</i>                      | 2.0%       |
| <i>Cycadopites</i> sp. (indet.)                 | 0.5%       |
| cf. <i>Densoisporites</i> sp.                   | +          |
| <i>Dictyophyllidites mortoni</i>                | 1.0%       |
| <i>Foveosporites</i> spp.                       | 0.5%       |
| <i>Granulatisporites</i> spp.                   | 1.5%       |
| <i>Guttatisporites visscheri</i>                | 0.5%       |
| <i>Inaperturopollenites</i> spp.                | 2.0%       |
| <i>Indospora clara</i>                          | +          |
| <i>Indusiisporites</i> sp.                      | +          |
| <i>Kraeuselisporites differens</i>              | +          |
| <i>Leiotriletes directus</i>                    | 12.5%      |
| <i>Lophotriletes bauhinae</i>                   | 0.5%       |
| cf. <i>Lundbladispota</i> sp.                   | 0.5%       |
| <i>Osmundacidites</i> spp.                      | 10.0%      |
| <i>Platysaccus queenslandi</i>                  | 0.5%       |
| <i>Platysaccus</i> sp. (indet.)                 | 0.5%       |
| <i>Punctatisporites</i> spp.                    | 2.0%       |
| <i>Rugulatisporites</i> sp.                     | 0.5%       |
| <i>Stereisporites</i> spp.                      | 2.0%       |
| <i>Striatissaccus novimundi</i>                 | 0.5%       |
| <i>Tigrisporites playfordi</i>                  | 0.5%       |
| <i>Triadispota crassa</i>                       | +          |
| <i>Verrucosisporites</i> spp.                   | 2.5%       |

## D.R.D. No. 4

## 127ft. 7in.

| Grey carb. shale                           | Count 200+ |
|--------------------------------------------|------------|
| cf. <i>Accinctisporites</i> sp.            | 0.5%       |
| <i>Alisporites</i> spp.                    | 26.5%      |
| <i>Alisporites australis</i>               | 0.5%       |
| <i>Alisporites townrovi</i>                | 0.5%       |
| <i>Apiculatisporis</i> sp.                 | 0.5%       |
| <i>Aratrisporites plicatus</i>             | 0.5%       |
| <i>Aratrisporites</i> cf. <i>rotundus</i>  | 1.0%       |
| <i>Aratrisporites</i> cf. <i>strigosus</i> | 0.5%       |
| <i>Aratrisporites tenuispinosus</i>        | 17.5%      |
| <i>Aratrisporites wollariensis</i>         | +          |
| <i>Aratrisporites</i> sp. (indet.)         | 1.0%       |
| <i>Araucariacites</i> sp.                  | 0.5%       |
| <i>Calamospora tener</i>                   | +          |
| <i>Calamospora</i> spp. (indet.)           | 1.0%       |
| <i>Converrucosisporites</i> spp.           | 1.5%       |
| <i>Convolutispora</i> spp.                 | 1.0%       |
| <i>Cyathidites breviradiatus</i>           | +          |
| <i>Cycadopites nitidus</i>                 | 0.5%       |
| <i>Dictyophyllidites mortoni</i>           | 1.5%       |
| <i>Granulatisporites</i> spp.              | 4.5%       |
| <i>Inaperturopollenites</i> spp.           | 3.5%       |
| <i>Leiotriletes directus</i>               | 4.5%       |
| <i>Lophotriletes</i> spp.                  | 1.5%       |
| <i>Nevesisporites limatulus</i>            | +          |
| <i>Osmundacidites</i> spp.                 | 20.5%      |
| <i>Platysaccus</i> cf. <i>queenslandi</i>  | +          |
| <i>Polypodiisporites ipsviciensis</i>      | 1.0%       |
| <i>Punctatisporites</i> spp.               | 1.5%       |
| <i>Retusotriletes</i> cf. <i>junior</i>    | 0.5%       |
| <i>Retusotriletes</i> sp. (indet.)         | 0.5%       |
| <i>Stereisporites</i> spp.                 | 4.5%       |
| <i>Striatissaccus novimundi</i>            | +          |
| <i>Succinctisporites</i> sp.               | 0.5%       |
| <i>Verrucosisporites</i> sp.               | 0.5%       |
| <i>Vitreisporites microsaccus</i>          | 0.5%       |
| <i>Vitreisporites pallidus</i>             | 1.0%       |

## 96ft. 8in.

| Grey carb. shale                          | Count 200+ |
|-------------------------------------------|------------|
| <i>Accinctisporites ligatus</i>           | 0.5%       |
| <i>Accinctisporites</i> sp. (indet.)      | 0.5%       |
| <i>Alisporites</i> spp.                   | 31.5%      |
| <i>Apiculatisporis</i> spp.               | 3.0%       |
| <i>Aratrisporites plicatus</i>            | 1.0%       |
| <i>Aratrisporites</i> cf. <i>rotundus</i> | 2.0%       |
| <i>Aratrisporites tenuispinosus</i>       | 2.5%       |
| <i>Aratrisporites</i> sp. (indet.)        | 0.5%       |
| <i>Baculatisporites</i> spp.              | 2.5%       |
| <i>Chordasporites australiensis</i>       | 0.5%       |
| <i>Conbaculatisporites</i> sp.            | 0.5%       |
| <i>Converrucosisporites cameroni</i>      | +          |
| <i>Cyathidites breviradiatus</i>          | +          |
| <i>Cycadopites nitidus</i>                | 0.5%       |
| <i>Densoisporites playfordi</i>           | +          |
| <i>Densosporites</i> sp.                  | 0.5%       |
| <i>Dictyophyllidites mortoni</i>          | 0.5%       |
| <i>Foveosporites</i> spp.                 | 1.5%       |
| <i>Granulatisporites</i> spp.             | 2.5%       |
| <i>Guttatisporites visscheri</i>          | +          |
| <i>Inaperturopollenites</i> spp.          | 1.5%       |
| <i>Leiotriletes directus</i>              | 13.0%      |
| <i>Leiotriletes</i> sp. (indet.)          | 1.0%       |
| <i>Lophotriletes</i> sp.                  | 1.5%       |
| <i>Osmundacidites</i> spp.                | 17.0%      |
| cf. <i>Osmundacidites</i> sp.             | 0.5%       |
| <i>Platysaccus queenslandi</i>            | +          |
| <i>Polypodiisporites ipsviciensis</i>     | 0.5%       |
| <i>Punctatisporites</i> sp.               | 2.0%       |
| <i>Retusotriletes</i> sp.                 | +          |
| <i>Stenozonotriletes</i> sp.              | 0.5%       |
| <i>Stereisporites</i> spp.                | 7.5%       |
| <i>Striatissaccus</i> sp.                 | 0.5%       |
| <i>Verrucosisporites</i> spp.             | 3.0%       |
| <i>Vitreisporites</i> sp.                 | 1.0%       |

## 92ft. 3in.

| Grey carb. shale                                 | Count 200+ |
|--------------------------------------------------|------------|
| <i>Accinctisporites ligatus</i>                  | +          |
| <i>Alisporites</i> spp.                          | 28.0%      |
| <i>Apiculatisporis</i> sp.                       | 0.5%       |
| <i>Aratrisporites plicatus</i>                   | 1.5%       |
| <i>Aratrisporites</i> cf. <i>rotundus</i>        | 2.0%       |
| <i>Aratrisporites strigosus</i>                  | 0.5%       |
| <i>Aratrisporites tenuispinosus</i>              | 8.0%       |
| <i>Aratrisporites wollariensis</i>               | +          |
| <i>Aratrisporites</i> sp. (indet.)               | 0.5%       |
| <i>Araucariacites</i> spp.                       | 1.5%       |
| <i>Calamospora</i> sp.                           | +          |
| <i>Chordasporites australiensis</i>              | +          |
| <i>Converrucosisporites</i> sp.                  | 0.5%       |
| <i>Cyathidites breviradiatus</i>                 | 1.0%       |
| <i>Cycadopites nitidus</i>                       | 2.0%       |
| <i>Cycadopites</i> sp. (indet.)                  | 0.5%       |
| <i>Dictyophyllidites mortoni</i>                 | 3.0%       |
| <i>Granulatisporites</i> spp.                    | 3.5%       |
| <i>Grebespora concentrica</i>                    | 0.5%       |
| <i>Guthoerlisporites cancellosus</i>             | +          |
| <i>Guttatisporites visscheri</i>                 | 0.5%       |
| <i>Inaperturopollenites</i> spp.                 | 6.0%       |
| <i>Leiotriletes directus</i>                     | 8.5%       |
| <i>Leiotriletes</i> sp. (indet.)                 | 1.5%       |
| <i>Lophotriletes bauhinae</i>                    | +          |
| <i>Neoraistrickia</i> cf. <i>taylorii</i>        | +          |
| <i>Nevesisporites limatulus</i>                  | +          |
| <i>Osmundacidites</i> spp.                       | 19.0%      |
| <i>Platysaccus queenslandi</i>                   | +          |
| <i>Platysaccus</i> sp. (indet.)                  | 0.5%       |
| <i>Polypodiisporites</i> cf. <i>ipsviciensis</i> | 0.5%       |
| <i>Punctatisporites</i> sp.                      | 0.5%       |
| cf. <i>Punctatisporites walkomi</i>              | 0.5%       |
| <i>Retusotriletes junior</i>                     | +          |
| <i>Retusotriletes</i> sp. (indet.)               | 0.5%       |



|                                              |      |
|----------------------------------------------|------|
| <i>Stereisporites</i> spp.                   | 3.5% |
| <i>Striatissaccus novimundi</i>              | 0.5% |
| <i>Striatissaccus</i> sp. (indet.)           | +    |
| <i>Sulcatissporites</i> cf. <i>kraeuseli</i> | 0.5% |
| <i>Tigrisporites playfordi</i>               | 1.0% |
| <i>Triadispora crassa</i>                    | 1.0% |
| <i>Verrucosissporites</i> spp.               | 1.0% |
| Striate bisaccate pollen (indet.)            | 0.5% |
| Acritarch (? <i>Michrhystridium</i> sp.)     | 0.5% |

## 56ft. 5in.

Grey carb. shale Count 200+

|                                                         |       |
|---------------------------------------------------------|-------|
| <i>Alisporites</i> spp.                                 | 36.0% |
| <i>Alisporites australis</i>                            | 0.5%  |
| <i>Apiculatisporis</i> spp.                             | 3.0%  |
| <i>Aratrisporites plicatus</i>                          | +     |
| <i>Aratrisporites tenuispinosus</i>                     | 5.0%  |
| <i>Aratrisporites</i> sp. (indet.)                      | 0.5%  |
| <i>Araucariacites</i> spp.                              | 1.0%  |
| <i>Chordasporites australiensis</i>                     | 0.5%  |
| <i>Converrucosissporites cameroni</i>                   | 0.5%  |
| <i>Cyathidites breviradiatus</i>                        | +     |
| cf. <i>Densosporites</i> sp.                            | 0.5%  |
| <i>Dictyophyllidites mortoni</i>                        | 1.0%  |
| <i>Equisetosporites steevesi</i>                        | 0.5%  |
| <i>Granulatisporites</i> spp.                           | 2.5%  |
| <i>Guthoerlisporites cancellosus</i>                    | +     |
| <i>Guttatisporites visscheri</i>                        | 0.5%  |
| <i>Inaperturopollenites</i> spp.                        | 1.5%  |
| <i>Leiotriletes directus</i>                            | 3.5%  |
| <i>Leiotriletes</i> sp. (indet.)                        | 0.5%  |
| <i>Lophotriletes</i> spp.                               | 2.0%  |
| <i>Platysaccus</i> sp. (indet.)                         | +     |
| <i>Nevesisporites limatulus</i>                         | 0.5%  |
| <i>Osmundacidites</i> spp. (incl. <i>O. wellmanii</i> ) | 32.5% |
| cf. <i>Osmundacidites</i> sp.                           | 0.5%  |
| <i>Platysaccus queenslandi</i>                          | 1.0%  |
| <i>Neoraistrickia</i> cf. <i>taylorii</i>               | +     |
| <i>Polypodiisporites ipsviciensis</i>                   | 1.0%  |
| <i>Retusotriletes</i> sp.                               | 0.5%  |
| <i>Rugulatisporites</i> sp.                             | 1.0%  |
| <i>Stereisporites antiquasporites</i>                   | +     |
| <i>Stereisporites</i> sp. (indet.)                      | 0.5%  |
| <i>Striatissaccus novimundi</i>                         | +     |
| <i>Tigrisporites playfordi</i>                          | 0.5%  |
| <i>Triadispora falcata</i>                              | +     |
| <i>Verrucosissporites</i> spp.                          | 1.5%  |
| <i>Vitreisporites microsaccus</i>                       | 1.0%  |
| Striate bisaccate pollen (indet.)                       | +     |

## D.R.D. No. 2

## 188ft. 3in.

Grey shale Count 200+

|                                           |       |
|-------------------------------------------|-------|
| <i>Acanthotriletes</i> sp.                | 0.5%  |
| <i>Accinctisporites ligatus</i>           | +     |
| <i>Alisporites</i> spp.                   | 48.5% |
| <i>Apiculatisporis</i> spp.               | 2.5%  |
| <i>Aratrisporites plicatus</i>            | +     |
| <i>Aratrisporites strigosus</i>           | +     |
| <i>Chordasporites australiensis</i>       | 0.5%  |
| <i>Converrucosissporites cameroni</i>     | 0.5%  |
| <i>Converrucosissporites</i> sp. (indet.) | 0.5%  |
| <i>Cycadopites nitidus</i>                | 4.0%  |
| <i>Cycadopites</i> spp. (indet.)          | 2.5%  |
| <i>Equisetosporites steevesi</i>          | +     |
| <i>Equisetosporites</i> sp. (indet.)      | 0.5%  |
| <i>Granulatisporites</i> spp.             | 3.0%  |
| <i>Grebespora concentrica</i>             | 0.5%  |
| <i>Guthoerlisporites cancellosus</i>      | 0.5%  |
| <i>Hamiapollenites insculptus</i>         | 1.0%  |
| <i>Inaperturopollenites</i> sp.           | 0.5%  |
| <i>Indospora reticulata</i>               | +     |
| <i>Indospora</i> sp. (indet.)             | +     |
| <i>Indusiisporites</i> sp.                | 0.5%  |

|                                           |       |
|-------------------------------------------|-------|
| <i>Leiotriletes directus</i>              | 4.0%  |
| <i>Lophotriletes bauhiniae</i>            | +     |
| <i>Lophotriletes</i> spp. (indet.)        | 4.5%  |
| <i>Neoraistrickia</i> cf. <i>taylorii</i> | 0.5%  |
| <i>Neoraistrickia</i> sp. (indet.)        | +     |
| <i>Osmundacidites</i> spp.                | 13.5% |
| <i>Platysaccus queenslandi</i>            | 1.5%  |
| <i>Platysaccus</i> sp. (indet.)           | 0.5%  |
| <i>Polypodiisporites ipsviciensis</i>     | 1.0%  |
| <i>Polypodiisporites</i> sp. (indet.)     | 0.5%  |
| <i>Punctatisporites</i> spp.              | 1.0%  |
| <i>Retusotriletes</i> sp.                 | +     |
| <i>Rugulatisporites</i> sp.               | 0.5%  |
| <i>Stereisporites</i> spp.                | 2.5%  |
| <i>Sulcosaccispora alaticonformis</i>     | 0.5%  |
| <i>Tigrisporites playfordi</i>            | 0.5%  |
| <i>Tuberculatosporites</i> sp.            | 0.5%  |
| <i>Verrucosissporites</i> spp.            | 2.0%  |
| <i>Vitreisporites microsaccus</i>         | +     |
| <i>Vitreisporites</i> sp. (indet.)        | 0.5%  |

## 99ft. 5in.

Grey shale Count 200+

|                                           |       |
|-------------------------------------------|-------|
| <i>Accinctisporites ligatus</i>           | +     |
| <i>Alisporites</i> spp.                   | 73.0% |
| <i>Apiculatisporis</i> spp.               | 3.5%  |
| <i>Aratrisporites</i> cf. <i>rotundus</i> | +     |
| <i>Calamospora tener</i>                  | 0.5%  |
| <i>Chordasporites australiensis</i>       | +     |
| <i>Convolutispora</i> sp.                 | 0.5%  |
| <i>Cyathidites breviradiatus</i>          | 0.5%  |
| <i>Cycadopites nitidus</i>                | 0.5%  |
| <i>Dictyophyllidites mortoni</i>          | 1.0%  |
| <i>Granulatisporites</i> spp.             | 1.0%  |
| <i>Grebespora concentrica</i>             | +     |
| <i>Guthoerlisporites cancellosus</i>      | +     |
| <i>Inaperturopollenites</i> spp.          | 1.5%  |
| <i>Indospora clara</i>                    | +     |
| <i>Leiotriletes directus</i>              | 6.0%  |
| <i>Lophotriletes bauhiniae</i>            | 0.5%  |
| <i>Osmundacidites</i> spp.                | 5.5%  |
| <i>Platysaccus queenslandi</i>            | 0.5%  |
| <i>Polypodiisporites ipsviciensis</i>     | 1.0%  |
| <i>Punctatisporites</i> spp.              | 1.0%  |
| <i>Stereisporites</i> spp.                | 1.5%  |
| <i>Sulcosaccispora alaticonformis</i>     | +     |
| <i>Triadispora falcata</i>                | 0.5%  |
| <i>Tuberculatosporites</i> sp.            | 0.5%  |
| <i>Verrucosissporites</i> spp.            | 1.0%  |

## 93ft. 7in.

Grey shale Count 200+

|                                           |       |
|-------------------------------------------|-------|
| <i>Alisporites</i> spp.                   | 73.0% |
| <i>Apiculatisporis</i> spp.               | 1.5%  |
| <i>Aratrisporites plicatus</i>            | +     |
| <i>Aratrisporites</i> cf. <i>rotundus</i> | +     |
| <i>Chordasporites australiensis</i>       | +     |
| <i>Converrucosissporites</i> sp.          | 0.5%  |
| <i>Cyathidites breviradiatus</i>          | 0.5%  |
| <i>Cycadopites nitidus</i>                | 0.5%  |
| <i>Dictyophyllidites mortoni</i>          | 1.5%  |
| <i>Granulatisporites</i> spp.             | 0.5%  |
| <i>Guttatisporites visscheri</i>          | 0.5%  |
| <i>Hamiapollenites insculptus</i>         | +     |
| <i>Inaperturopollenites</i> sp.           | 0.5%  |
| <i>Indospora reticulata</i>               | +     |
| <i>Leiotriletes directus</i>              | 5.0%  |
| <i>Lophotriletes bauhiniae</i>            | +     |
| <i>Neoraistrickia</i> cf. <i>taylorii</i> | +     |
| <i>Osmundacidites</i> spp.                | 10.5% |
| <i>Platysaccus</i> sp.                    | 0.5%  |
| <i>Polypodiisporites ipsviciensis</i>     | 1.0%  |
| <i>Punctatisporites</i> sp.               | 0.5%  |
| <i>Punctatosporites walkomi</i>           | 0.5%  |



|                                   |      |
|-----------------------------------|------|
| <i>Stereisporites</i> spp.        | 1.5% |
| <i>Tigrisporites playfordi</i>    | +    |
| <i>Verrucosporites</i> spp.       | 1.0% |
| <i>Vitreisporites microsaccus</i> | +    |
| Striate bisaccate pollen (indet.) | 0.5% |

## D.R.D. No. 9

## 856ft. 2in.

Grey shale with red bands      Count 200+

|                                           |       |
|-------------------------------------------|-------|
| <i>Acanthotriletes</i> sp.                | 1.0%  |
| <i>Accinctisporites</i> sp.               | +     |
| <i>Alisporites</i> spp.                   | 54.0% |
| <i>Apiculatisporis clematidis</i>         | 0.5%  |
| <i>Apiculatisporis</i> spp. (indet.)      | 5.0%  |
| <i>Aratrisporites plicatus</i>            | +     |
| <i>Aratrisporites</i> cf. <i>rotundus</i> | +     |
| <i>Aratrisporites strigosus</i>           | 0.5%  |
| <i>Araucariacites</i> sp.                 | 0.5%  |
| <i>Clavatriletes</i> cf. <i>hammenii</i>  | +     |
| <i>Converrucosporites cameroni</i>        | 1.5%  |
| <i>Converrucosporites</i> spp.            | 2.0%  |
| <i>Cycadopites nitidus</i>                | 2.5%  |
| <i>Densoisporites playfordi</i>           | +     |
| <i>Dictyophyllidites mortoni</i>          | 1.0%  |
| <i>Foveosporites</i> sp.                  | 0.5%  |
| <i>Granulatisporites</i> sp.              | 0.5%  |
| <i>Grebespora concentrica</i>             | +     |
| <i>Guttatisporites visscheri</i>          | +     |
| <i>Hamiapollenites insculptus</i>         | 0.5%  |
| <i>Inaperturopollenites</i> sp.           | 0.5%  |
| cf. <i>Kraeuselisporites</i> sp.          | 0.5%  |
| <i>Leiotriletes directus</i>              | 6.5%  |
| <i>Lophotriletes</i> spp.                 | 2.0%  |
| <i>Neoraistrickia</i> cf. <i>taylorii</i> | 0.5%  |
| <i>Neoraistrickia</i> sp. (indet.)        | 0.5%  |
| <i>Osmundacidites</i> spp.                | 7.5%  |
| <i>Platysaccus queenslandi</i>            | +     |
| <i>Platysaccus</i> sp. (indet.)           | 1.0%  |
| <i>Punctatisporites</i> spp.              | 1.5%  |
| <i>Retusotriletes junior</i>              | +     |
| <i>Rugulatisporites</i> sp.               | +     |
| <i>Stereisporites</i> spp.                | 4.5%  |
| <i>Tigrisporites playfordi</i>            | 0.5%  |
| <i>Verrucosporites</i> spp.               | 1.5%  |
| <i>Vitreisporites microsaccus</i>         | 0.5%  |
| <i>Vitreisporites pallidus</i>            | 1.0%  |
| <i>Vitreisporites</i> sp. (indet.)        | 0.5%  |
| Striate bisaccate pollen (indet.)         | 1.0%  |

## 850ft. 3in.

Grey shale      Count 200+

|                                         |       |
|-----------------------------------------|-------|
| <i>Acanthotriletes</i> sp.              | 1.0%  |
| <i>Accinctisporites ligatus</i>         | +     |
| <i>Alisporites</i> spp.                 | 40.0% |
| <i>Apiculatisporis</i> spp.             | 3.5%  |
| <i>Aratrisporites</i> sp.               | +     |
| <i>Araucariacites</i> spp.              | 2.5%  |
| <i>Calamospora tener</i>                | 0.5%  |
| <i>Conbaculatisporites</i> sp.          | 0.5%  |
| <i>Converrucosporites cameroni</i>      | 0.5%  |
| <i>Converrucosporites</i> spp. (indet.) | 2.0%  |
| <i>Convolutispora</i> sp.               | 0.5%  |
| <i>Cycadopites nitidus</i>              | 2.5%  |
| <i>Cycadopites</i> sp. (indet.)         | 1.0%  |
| cf. <i>Densoisporites</i> sp.           | +     |
| <i>Dictyophyllidites harrisii</i>       | +     |
| <i>Dictyophyllidites mortoni</i>        | 2.0%  |
| cf. <i>Equisetosporites</i> sp.         | 0.5%  |
| <i>Granulatisporites</i> spp.           | 3.5%  |
| <i>Inaperturopollenites</i> spp.        | 3.0%  |
| <i>Kraeuselisporites</i> sp.            | +     |
| <i>Leiotriletes directus</i>            | 9.5%  |
| <i>Leiotriletes</i> sp. (indet.)        | 0.5%  |
| <i>Lophotriletes bauhiniiae</i>         | +     |

|                                           |       |
|-------------------------------------------|-------|
| <i>Lophotriletes</i> sp. (indet.)         | 1.0%  |
| <i>Neoraistrickia</i> cf. <i>taylorii</i> | +     |
| <i>Osmundacidites</i> spp.                | 12.5% |
| <i>Platysaccus queenslandi</i>            | 1.0%  |
| <i>Rugulatisporites trisinus</i>          | 1.0%  |
| <i>Rugulatisporites</i> sp. (indet.)      | 0.5%  |
| <i>Stenozonotriletes</i> sp.              | 0.5%  |
| <i>Stereisporites</i> spp.                | 7.5%  |
| <i>Tigrisporites playfordi</i>            | 0.5%  |
| <i>Verrucosporites</i> spp.               | 1.5%  |
| <i>Vitreisporites pallidus</i>            | +     |
| <i>Vitreisporites</i> sp. (indet.)        | 0.5%  |
| Striate bisaccate pollen (indet.)         | +     |

## 784ft. 5in.

Grey carb. shale      Count 200+

|                                        |       |
|----------------------------------------|-------|
| <i>Acanthotriletes</i> sp.             | 1.0%  |
| <i>Alisporites</i> spp.                | 54.5% |
| <i>Apiculatisporis</i> spp.            | 1.5%  |
| <i>Conbaculatisporites</i> sp.         | 0.5%  |
| <i>Converrucosporites cameroni</i>     | 0.5%  |
| <i>Converrucosporites</i> sp. (indet.) | 0.5%  |
| <i>Convolutispora</i> sp.              | 0.5%  |
| <i>Cycadopites nitidus</i>             | 4.0%  |
| <i>Dictyophyllidites mortoni</i>       | 2.0%  |
| <i>Granulatisporites</i> spp.          | 3.5%  |
| <i>Inaperturopollenites</i> spp.       | 2.0%  |
| <i>Leiotriletes directus</i>           | 10.5% |
| <i>Leiotriletes</i> sp. (indet.)       | 0.5%  |
| <i>Lophotriletes</i> spp.              | 1.0%  |
| <i>Osmundacidites</i> spp.             | 7.5%  |
| <i>Platysaccus</i> sp.                 | 1.0%  |
| <i>Rugulatisporites trisinus</i>       | +     |
| <i>Rugulatisporites</i> sp. (indet.)   | 1.0%  |
| <i>Stereisporites</i> spp.             | 4.5%  |
| <i>Tuberculatosporites</i> sp.         | 0.5%  |
| <i>Verrucosporites</i> spp.            | 3.0%  |
| <i>Vitreisporites pallidus</i>         | +     |

## 597ft. 11in.

Shale      Count 200+

|                                               |       |
|-----------------------------------------------|-------|
| <i>Acanthotriletes</i> sp.                    | 0.5%  |
| <i>Alisporites</i> spp.                       | 61.0% |
| <i>Aratrisporites</i> cf. <i>rotundus</i>     | 6.5%  |
| <i>Aratrisporites</i> sp. (indet.)            | 0.5%  |
| <i>Araucariacites</i> spp.                    | 1.5%  |
| <i>Calamospora</i> sp.                        | 0.5%  |
| <i>Converrucosporites</i> cf. <i>cameroni</i> | 0.5%  |
| <i>Cycadopites nitidus</i>                    | +     |
| <i>Dictyophyllidites</i> cf. <i>harrisii</i>  | 0.5%  |
| <i>Dictyophyllidites mortoni</i>              | 1.5%  |
| <i>Inaperturopollenites</i> spp.              | 3.0%  |
| <i>Leiotriletes directus</i>                  | 5.5%  |
| <i>Lophotriletes bauhiniiae</i>               | 0.5%  |
| <i>Lophotriletes</i> sp. (indet.)             | 1.0%  |
| <i>Osmundacidites</i> spp.                    | 7.0%  |
| <i>Punctatisporites</i> sp.                   | 0.5%  |
| <i>Rugulatisporites trisinus</i>              | 0.5%  |
| <i>Rugulatisporites</i> sp. (indet.)          | 0.5%  |
| <i>Stereisporites</i> spp.                    | 6.0%  |
| <i>Tuberculatosporites</i> sp.                | 0.5%  |
| <i>Verrucosporites</i> spp.                   | 1.0%  |
| <i>Vitreisporites pallidus</i>                | 0.5%  |
| Striate bisaccate pollen (indet.)             | 0.5%  |

## 584ft. 7in.

Shale      Count 200+

|                                     |       |
|-------------------------------------|-------|
| <i>Alisporites</i> spp.             | 54.5% |
| <i>Apiculatisporis</i> spp.         | 2.0%  |
| <i>Araucariacites</i> spp.          | 2.0%  |
| <i>Calamospora</i> sp.              | 1.5%  |
| <i>Chordasporites australiensis</i> | 0.5%  |



|                                          |       |
|------------------------------------------|-------|
| <i>Converrucosisporites cameroni</i>     | +     |
| <i>Converrucosisporites</i> sp. (indet.) | 0.5%  |
| <i>Cycadopites nitidus</i>               | 2.5%  |
| <i>Dictyophyllidites mortoni</i>         | 2.0%  |
| <i>Dictyophyllidites</i> sp. (indet.)    | 0.5%  |
| cf. <i>Dictyophyllidites</i> sp.         | 0.5%  |
| <i>Foveosporites</i> sp.                 | 0.5%  |
| <i>Granulatisporites</i> sp.             | 1.0%  |
| <i>Inaperturopollenites</i> spp.         | 2.5%  |
| <i>Leiotriletes directus</i>             | 13.5% |
| <i>Osmundacidites</i> spp.               | 7.0%  |
| <i>Platysaccus queenslandi</i>           | 0.5%  |
| <i>Punctatisporites</i> spp.             | 2.0%  |
| <i>Rugulatisporites trisinus</i>         | 0.5%  |
| <i>Rugulatisporites</i> sp. (indet.)     | 1.0%  |
| <i>Stereisporites</i> spp.               | 2.5%  |
| <i>Sulcosaccispora alaticonformis</i>    | 0.5%  |
| Bisaccate pollen (indet.)                | 0.5%  |
| Striate bisaccate pollen (indet.)        | 0.5%  |

## 559ft. 3in.

Shale Count 100

|                                   |     |
|-----------------------------------|-----|
| <i>Alisporites</i> spp.           | 58% |
| <i>Calamospora</i> sp.            | 2%  |
| <i>Dictyophyllidites mortoni</i>  | 4%  |
| <i>Granulatisporites</i> sp.      | 1%  |
| <i>Inaperturopollenites</i> spp.  | 5%  |
| <i>Leiotriletes directus</i>      | 11% |
| <i>Leiotriletes</i> sp. (indet.)  | 1%  |
| <i>Osmundacidites</i> spp.        | 4%  |
| <i>Platysaccus queenslandi</i>    | 1%  |
| <i>Punctatisporites</i> spp.      | 3%  |
| <i>Retusotriletes junior</i>      | 1%  |
| <i>Stereisporites</i> spp.        | 6%  |
| <i>Verrucosisporites</i> sp.      | 1%  |
| <i>Vitreisporites microsaccus</i> | 1%  |
| <i>Vitreisporites pallidus</i>    | 1%  |

## 523ft. 6in.

Shale Count 200+

|                                                      |       |
|------------------------------------------------------|-------|
| <i>Alisporites</i> spp. (incl. <i>A. australis</i> ) | 39.0% |
| <i>Aratrisporites</i> cf. <i>rotundus</i>            | 1.0%  |
| <i>Araucariacites</i> sp.                            | 0.5%  |
| <i>Calamospora</i> sp.                               | 0.5%  |
| <i>Cycadopites grandis</i>                           | 0.5%  |
| <i>Converrucosisporites</i> cf. <i>cameroni</i>      | +     |
| <i>Cycadopites granulatus</i>                        | 1.0%  |
| <i>Cycadopites nitidus</i>                           | 10.5% |
| <i>Cycadopites</i> sp. (indet.)                      | 0.5%  |
| <i>Nevesisporites limatulus</i>                      | +     |
| <i>Densoisporites playfordi</i>                      | 0.5%  |
| <i>Dictyophyllidites mortoni</i>                     | 1.0%  |
| <i>Granulatisporites</i> spp.                        | 2.5%  |
| <i>Inaperturopollenites</i> spp.                     | 4.0%  |
| <i>Grebespora concentrica</i>                        | +     |
| <i>Indusiisporites</i> sp.                           | 0.5%  |
| <i>Leiotriletes directus</i>                         | 13.0% |
| <i>Osmundacidites</i> spp.                           | 10.0% |
| <i>Polypodiisporites ipsviciensis</i>                | 0.5%  |
| <i>Punctatisporites</i> spp.                         | 2.5%  |
| <i>Stereisporites</i> spp.                           | 8.0%  |
| <i>Triadispota falcata</i>                           | 0.5%  |
| <i>Verrucosisporites</i> spp.                        | 1.5%  |
| <i>Vitreisporites microsaccus</i>                    | 0.5%  |
| Striate bisaccate pollen                             | 0.5%  |

## 495ft. 4in.

Shale Count 100

|                                           |     |
|-------------------------------------------|-----|
| <i>Alisporites</i> spp.                   | 49% |
| <i>Aratrisporites</i> cf. <i>rotundus</i> | 1%  |
| <i>Calamospora</i> sp.                    | 1%  |
| <i>Cycadopites nitidus</i>                | 2%  |

|                                  |     |
|----------------------------------|-----|
| <i>Dictyophyllidites mortoni</i> | 5%  |
| <i>Inaperturopollenites</i> spp. | 10% |
| <i>Leiotriletes directus</i>     | 15% |
| <i>Leiotriletes</i> sp. (indet.) | 1%  |
| <i>Osmundacidites</i> spp.       | 7%  |
| <i>Platysaccus queenslandi</i>   | 1%  |
| <i>Punctatisporites</i> sp.      | 1%  |
| <i>Stereisporites</i> spp.       | 5%  |
| <i>Verrucosisporites</i> sp.     | 1%  |
| <i>Vitreisporites</i> sp.        | 1%  |

## 491ft. 11in.

Shale Count 200+

|                                           |       |
|-------------------------------------------|-------|
| <i>Alisporites</i> spp.                   | 48.0% |
| <i>Apiculatisporis</i> sp.                | 1.0%  |
| <i>Aratrisporites</i> cf. <i>rotundus</i> | 6.5%  |
| <i>Calamospora</i> cf. <i>tener</i>       | 0.5%  |
| <i>Converrucosisporites</i> sp.           | 0.5%  |
| <i>Cycadopites granulatus</i>             | 0.5%  |
| <i>Cycadopites nitidus</i>                | 0.5%  |
| <i>Dictyophyllidites harrisii</i>         | +     |
| <i>Dictyophyllidites mortoni</i>          | 3.0%  |
| <i>Granulatisporites</i> spp.             | 2.5%  |
| <i>Inaperturopollenites</i> spp.          | 2.0%  |
| <i>Indusiisporites</i> sp.                | 0.5%  |
| <i>Leiotriletes directus</i>              | 10.0% |
| <i>Limitisporites</i> sp.                 | +     |
| <i>Lophotriletes bauhiniae</i>            | 0.5%  |
| <i>Neoraistrickia</i> cf. <i>taylorii</i> | 1.0%  |
| <i>Osmundacidites</i> spp.                | 13.5% |
| <i>Platysaccus</i> sp.                    | 0.5%  |
| <i>Rugulatisporites</i> sp.               | 1.0%  |
| <i>Stereisporites</i> spp.                | 5.0%  |
| <i>Sulcosaccispora alaticonformis</i>     | +     |
| <i>Triadispota falcata</i>                | 1.0%  |
| <i>Verrucosisporites</i> spp.             | 1.0%  |
| <i>Vitreisporites microsaccus</i>         | 0.5%  |
| <i>Vitreisporites pallidus</i>            | 0.5%  |

## 491ft. 4in.

Shale Count 200

|                                           |       |
|-------------------------------------------|-------|
| <i>Acanthotriletes</i> sp.                | 0.5%  |
| <i>Alisporites</i> spp.                   | 46.0% |
| <i>Apiculatisporis</i> sp.                | 0.5%  |
| <i>Aratrisporites</i> cf. <i>rotundus</i> | 4.5%  |
| <i>Calamospora</i> sp.                    | 0.5%  |
| <i>Cycadopites nitidus</i>                | 0.5%  |
| <i>Dictyophyllidites mortoni</i>          | 0.5%  |
| <i>Dictyophyllidites</i> sp. (indet.)     | 0.5%  |
| <i>Granulatisporites</i> spp.             | 3.5%  |
| <i>Inaperturopollenites</i> spp.          | 1.5%  |
| <i>Indusiisporites</i> sp.                | 1.0%  |
| <i>Leiotriletes directus</i>              | 13.5% |
| <i>Lophotriletes bauhiniae</i>            | 0.5%  |
| <i>Osmundacidites</i> spp.                | 15.0% |
| <i>Platysaccus queenslandi</i>            | 0.5%  |
| <i>Punctatisporites</i> spp.              | 2.0%  |
| <i>Retusotriletes junior</i>              | 0.5%  |
| <i>Stereisporites</i> spp.                | 4.5%  |
| <i>Triadispota falcata</i>                | 0.5%  |
| cf. <i>Triadispota</i> sp.                | 0.5%  |
| <i>Verrucosisporites</i> spp.             | 2.0%  |
| <i>Vitreisporites microsaccus</i>         | 0.5%  |
| <i>Vitreisporites</i> sp. (indet.)        | 0.5%  |

## 431ft. 2in.

Carb. shale Count 200+

|                                           |       |
|-------------------------------------------|-------|
| <i>Accinctisporites ligatus</i>           | +     |
| <i>Alisporites</i> spp.                   | 62.5% |
| <i>Apiculatisporis</i> spp.               | 1.0%  |
| <i>Aratrisporites</i> cf. <i>rotundus</i> | 9.5%  |



|                                                 |      |                                       |      |
|-------------------------------------------------|------|---------------------------------------|------|
| <i>Aratrisporites</i> cf. <i>strigosus</i>      | +    | <i>Platysaccus queenslandi</i>        | 0.5% |
| <i>Converrucosisporites</i> cf. <i>cameroni</i> | 1.0% | <i>Platysaccus</i> sp. (indet.)       | 0.5% |
| <i>Cycadopites nitidus</i>                      | 3.5% | <i>Stereisporites</i> spp.            | 2.0% |
| <i>Dictyophyllidites mortoni</i>                | 0.5% | <i>Sulcosaccispora alaticonformis</i> | +    |
| <i>Granulatisporites</i> sp.                    | 1.0% | <i>Triadispora falcata</i>            | 1.5% |
| <i>Grebespora concentrica</i>                   | +    | <i>Verrucosisporites</i> spp.         | 1.0% |
| cf. <i>Indusiiporites</i> sp.                   | 0.5% | <i>Vitreisporites microsaccus</i>     | 0.5% |
| <i>Leiotriletes directus</i>                    | 4.0% | <i>Vitreisporites pallidus</i>        | 0.5% |
| <i>Lophotriletes bauhiniae</i>                  | +    | <i>Vitreisporites</i> sp. (indet.)    | 1.0% |
| <i>Nevesisporites limatulus</i>                 | 0.5% | Striate bisaccate pollen (indet.)     | 0.5% |
| <i>Osmundacidites</i> spp.                      | 7.0% | <i>Chordasporites australiensis</i>   | 0.5% |

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FIG. 2. MICROFLORAL DISTRIBUTION DIAGRAM : D.R.D. No 9

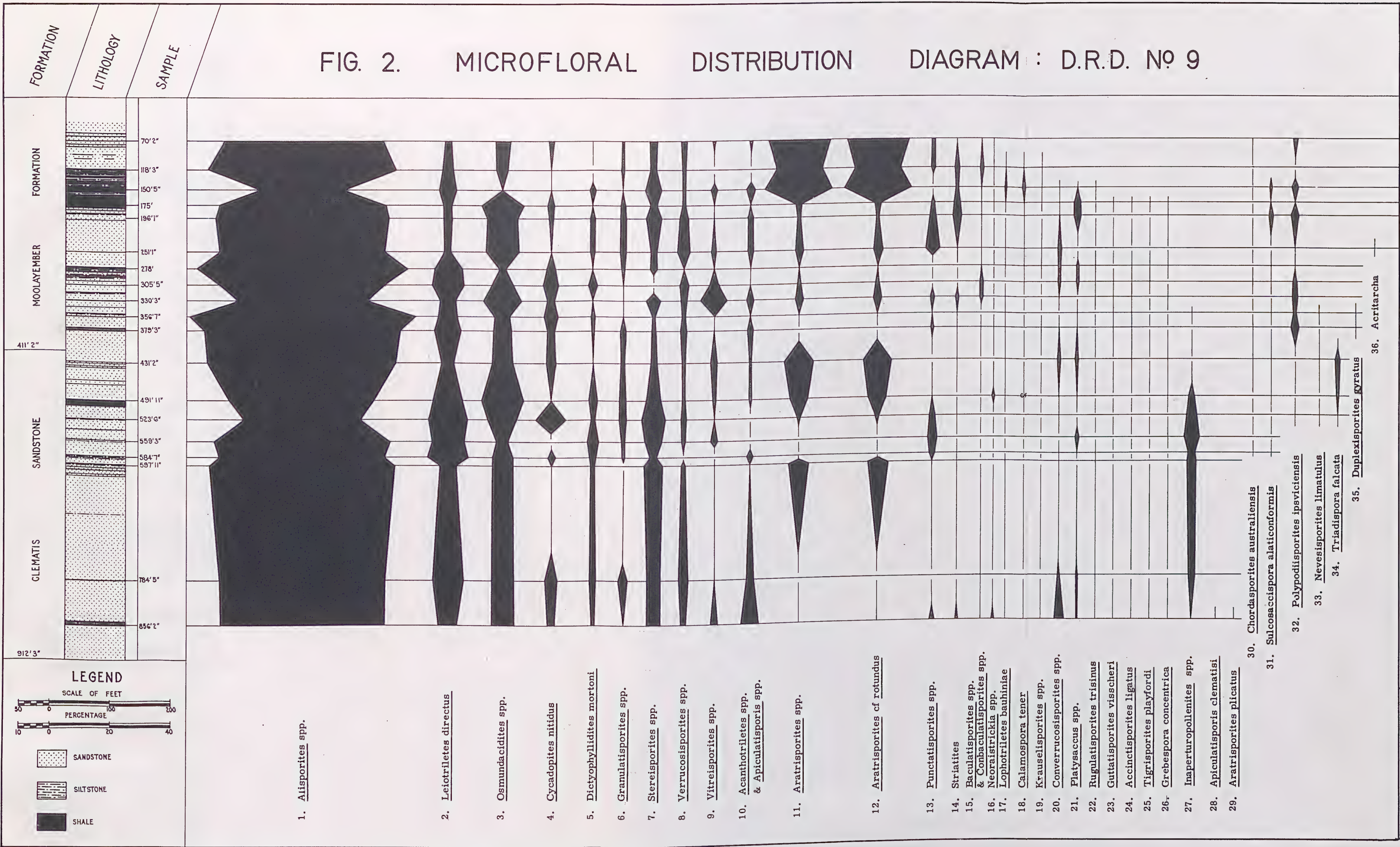
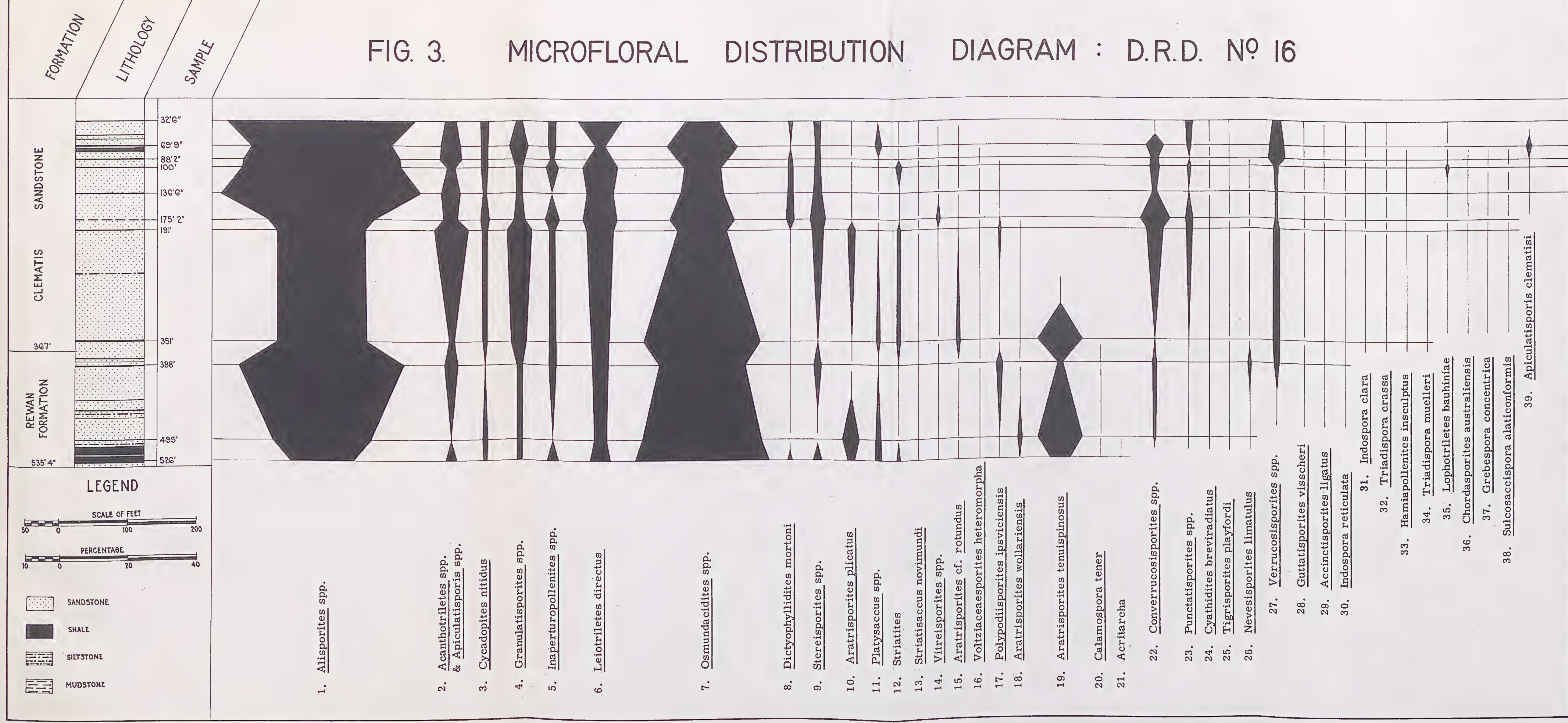








FIG. 3. MICROFLORAL DISTRIBUTION DIAGRAM : D.R.D. Nº 16

























QUEENSLAND  
DEPARTMENT OF MINES

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GEOLOGICAL SURVEY OF QUEENSLAND  
(J. T. Woods, Chief Government Geologist)

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JURASSIC SEDIMENTS OF THE  
NORTHERN SURAT BASIN,  
QUEENSLAND

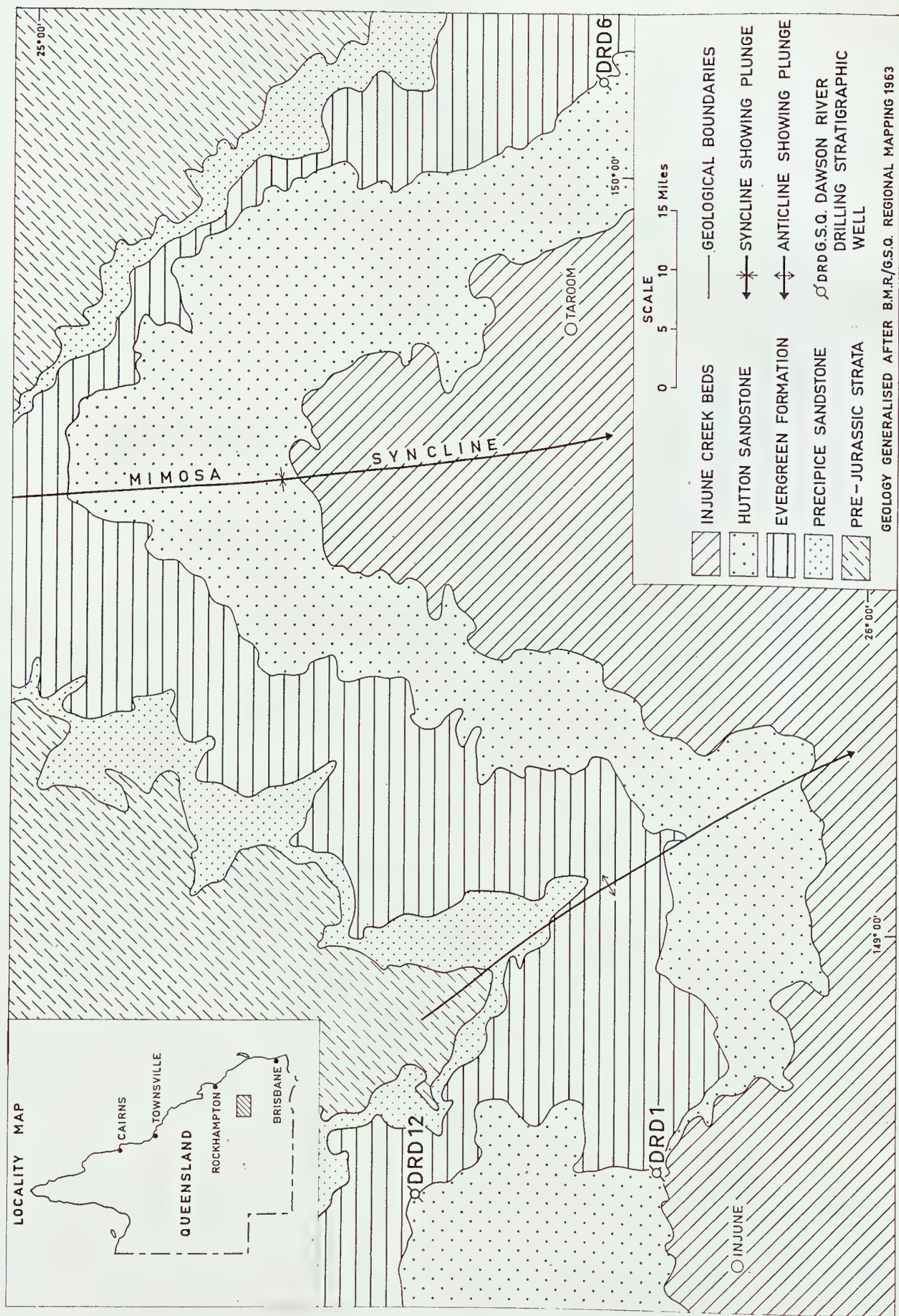
By R. F. REISER and A. J. WILLIAMS



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TEXT-FIG. 1. Map showing the locations of G.S.Q. D.R.D. Nos. 1, 6, and 12, and the Jurassic geology of the northern part of the Surat Basin.



# PALYNOLOGY OF THE LOWER JURASSIC SEDIMENTS OF THE NORTHERN SURAT BASIN, QUEENSLAND

by

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Geological Survey of Queensland

## ABSTRACT

Fifty-nine species of spores and pollen and two groups of microplankton are recorded from the Precipice Sandstone, Evergreen Formation, and the lower Hutton Sandstone of the Surat Basin, Queensland. Eight new species are described. The microfloral distribution is discussed, and illustrated by charts based on three stratigraphical sections; one new zone and two new subzones are formally proposed. A Liassic age is suggested for the upper part of the sequence, agreeing with previous palynological work; it is possible that the lower part may range down into the Rhaetic.

## INTRODUCTION

The Jurassic-Cretaceous Surat Basin is situated in south-eastern Queensland and northern New South Wales; it is the eastern lobe of the Great Artesian Basin. The present study is concerned with the Lower Jurassic part of the sequence in the basin, and follows on from the work of de Jersey and Paten (1964). The units studied are

Hutton Sandstone (lower part only)  
Evergreen Formation  
Precipice Sandstone

The stratigraphy of these sediments has been reviewed by Hogetoorn (1967) and is only summarized here. The basement rocks of the basin range in age from Devonian to Triassic; these are largely sediments of the Bowen Basin, the known youngest of which constitute the Moolayember Formation, dated as Middle Triassic (de Jersey and Hamilton, 1967). Following the folding, faulting and erosion of these beds, the Precipice Sandstone was laid down. This quartzose sandstone may be divided into two parts, the upper more finely grained and less permeable than the lower, and with more shale bands. The succeeding Evergreen Formation comprises overall more finely grained sediments, with a much higher proportion of shale. In its upper part two members are defined: the well-sorted Boxvale Sandstone which wedges out eastwards, and immediately overlying it, the Westgrove Ironstone Member. The latter is a thin oolitic chamositic deposit of wide areal extent; it becomes thinner and more clearly oolitic to the east. Above the Evergreen Formation only the lower part of the succeeding Hutton Sandstone was available for study.

Except possibly for the Westgrove Ironstone Member, the sediments were deposited under continental conditions. No marine macrofossils have been found. Only one occurrence of foraminifera has been reported from the upper Evergreen Formation at Moonie (Evans, 1966). Plant macrofossils have been recorded by Whitehouse (1955) and in unpublished records of the Bureau of Mineral Resources; but these, although of general Jurassic aspect, are not useful for more precise dating. Plant microfossils have proved to be the only widespread, stratigraphically useful fossils within these sediments; de Jersey, Evans, and Paten have published papers on the palynology of the Surat Basin (see pp. 17, 19).

Previous microfloral investigations have been based largely on samples from conventional and side-wall cores, and cuttings, from oil exploration and development wells, and from shallow auger holes. The Dawson River Drilling Programme of the Mines Department has provided continuous cores from the type areas of the formations studied. This has allowed a standard reference section to be established in these units, which may be used to provide a basis for correlation with other areas. The samples were obtained from holes drilled by the Drilling Branch, Department of Mines; geological supervision was exercised by the Petroleum Section, Geological Survey of Queensland (G.S.Q.). These holes, comprising Dawson River Drilling (D.R.D.) Nos. 1, 6 and 12 were located in the northern part of the basin; D.R.D. Nos. 1 and 12 in the west, D.R.D. No. 6 in the east (see text-fig. 1). The lithology and units cored are summarized in the microfloral distribution charts text-figs 2 and 3). Gray (1968) has reported on the Dawson River Drilling Programme.

## PROCESSING OF SAMPLES

Two methods of processing were used. Samples from D.R.D. Nos. 1 and 12 and the sample from D.R.D. No. 6 at 293 ft. 2 in. were processed at the Geological Survey by the method described by de Jersey and Hamilton (1967, p. 2). The remainder of the samples from D.R.D. No. 6 were processed at the University of Queensland as follows. About 10 grams of material were crushed finely, and immersed in 150 mls. cold hydrofluoric acid for several days (calcareous samples were first treated with hydrochloric acid). The mixture was then boiled and the residue treated repeatedly with hot 50 per cent. hydrochloric acid until free of fluorides. It was



subjected to controlled oxidation by Schulze solution for periods up to one hour. Finally, oxidised organic matter was removed in ammonium hydroxide solution. These residues were mounted in glycerine jelly under No. 0 cover slips and sealed with gold size. Some preparations were stained with safranin O.

### SYSTEMATIC PALYNOLOGY

Nomenclature is based on the International Code of Botanical Nomenclature (1961). There are no agreed rules for the suprageneric classification of dispersed spores, although several systems have been proposed; these are discussed in Dettmann (1963), Potonié (1966), Neves and Owens (1966), and Smith & Butterworth (1967). In this study the system proposed by Dettmann (1963) for the Anteturma Sporites is followed. The system proposed by Potonié (1958, 1960) is used for the suprageneric classification of the Anteturma Pollenites. Descriptive terms are those of Dettmann (1963, p. 16), except that the term "coni" is used in place of "spinulae". In cingulate spores the term "spore body" refers to the body of the spore inside the cingulum.

All descriptions and dimensions are based on at least twenty specimens except where otherwise stated. The figured specimens, including holotypes, are stored in the collections of either the Geological Survey of Queensland, or the Department of Geology and Mineralogy, University of Queensland. Catalogued slide numbers quoted are of the Geological Survey (prefixed S) and the University (prefixed R). Co-ordinates given are respectively the "north-south" and "east-west" mechanical stage readings of Zeiss microscope CZ 4303529. A reference slide for the co-ordinates is stored at the Geological Survey; in addition holotypes are ringed.

### SYSTEMATIC DESCRIPTIONS

|               |                                                           |
|---------------|-----------------------------------------------------------|
| Anteturma     | SPORITES H. Potonié, 1893                                 |
| Turma         | TRILETES Reinsch <i>emend.</i><br>Dettmann, 1963          |
| Suprasubturma | ACAVATITRILETES Dettmann, 1963                            |
| Subturma      | AZONOTRILETES Lubert <i>emend.</i><br>Dettmann, 1963      |
| Infraturma    | LAEVIGATI Bennie & Kidston<br><i>emend.</i> Potonié, 1956 |

Genus *Cyathidites* Couper, 1953

*Type species* (by original designation).—*Cyathidites australis* Couper, 1953.

*Cyathidites australis* Couper, 1953

Pl. 1, fig. 3

*Distribution*.—Recorded world-wide from Mesozoic sediments. Evergreen Formation, lower Hutton Sandstone (this paper).

*Cyathidites minor* Couper, 1953

Pl. 1, fig. 2

*Distribution*.—Recorded world-wide from Mesozoic sediments. Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Stereisporites* Pflug, 1953

*Type species* (by original designation).—*Stereisporites stereoides* (Potonié & Venitz) Pflug, 1953.

*Stereisporites antiquasporites* (Wilson & Webster)  
Dettmann, 1963

*Distribution*.—Frequently recorded from Mesozoic and Tertiary strata. Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

*Stereisporites perforatus* Leschik, 1955

Pl. 1, fig. 1

*Distribution*.—Known previously from the Liassic of Poland (Rogalska, 1954, 1956); the Keuper of Switzerland (Leschik, 1955); the Rhaeto-Liassic of South Australia (Playford & Dettmann, 1965); the Triassic of Tasmania (Playford, 1965); the Jurassic of Mount Morgan, Queensland (Playford & Cornelius, 1967); listed from the Triassic and Jurassic of Queensland (Hill, Playford, & Woods, 1965, 1966). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

*Stereisporites* sp.

*Description*.—Spores trilete. Amb. circular to subcircular. Laesurae  $\frac{1}{2}$ –1 amb radius in length; simple, or may have lips up to 2.0 microns wide. Exine smooth to scabrate, approximately 1.0 micron thick. Equatorial diameter 21.0–40.0 microns.

*Distribution*.—Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Dictyophyllidites* Couper *emend.*  
Dettmann, 1963

*Type species* (by original designation).—*Dictyophyllidites harrisii* Couper, 1958.

*Dictyophyllidites mortoni* (de Jersey) Playford &  
Dettmann, 1965

Pl. 1, fig. 4

*Distribution*.—Triassic and Jurassic of Queensland (de Jersey 1959, 1962, 1963, 1964; Paten, 1967; de Jersey & Hamilton, 1967); Rhaeto-Liassic of South Australia (Playford & Dettmann, 1965). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Infraturma APICULATI Bennie & Kidston  
*emend.* Potonié, 1956

Genus *Osmundacidites* Couper, 1953

*Type Species* (by original designation).—*Osmundacidites wellmanii* Couper, 1953.



*Osmundacidites wellmanii* Couper, 1953

*Distribution*.—Frequently recorded from Jurassic and Cretaceous strata. Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Granulatisporites* Ibrahim emend. Potonié & Kremp, 1954

*Type species* (by original designation, cited by Schopf, Wilson, & Bentall, 1944, p. 33).—*Granulatisporites granulatus* Ibrahim, 1933.

*Granulatisporites* sp.

Pl. 1, fig. 5

*Description*.—Spores trilete. Amb subtriangular with slightly concave (rarely convex) sides, and rounded apices. Laesurae simple, reaching equator. Dense sculpture of low grana and a few coni, up to 1.0 micron high. Exine approximately 1.0 micron thick. Equatorial diameter (18 specimens) 28.0 (31.0) 38.0 microns.

*Remarks*.—Two similar specimens were recorded with arcuate folds proximally.

*Comparison*.—The specimens compare closely with *Granulatisporites asper* (Nilsson) Playford & Dettmann, 1965; they have a more restricted size range than *G. asper* and have more concave sides. Their simple laesurae contrast with the lipped laesurae of *Granulatisporites* cf. *G. asper* (Playford & Dettmann, 1965). *Granulatisporites minor* de Jersey, 1959 has granulate-papillate sculpture. *Concavisporites infirmus* Balme, 1957 has a kyrtome and the sculpture is "finely rugose or incipiently microreticulate." The specimens are similar to *Concavisporites subgranulosus* Couper, 1958, but have denser sculpture and thinner exine.

*Distribution*.—Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Apiculatisporis* Potonié & Kremp, 1956

*Type species* (by original designation).—*Apiculatisporis aculeatus* (Ibrahim) Potonié, 1956.

*Apiculatisporis taroomensis* sp. nov.

Pl. 1, figs 6–8

*Diagnosis*.—Spores trilete. Amb subcircular to convexly subtriangular. Laesurae simple, often with adjacent folds; straight to slightly sinuous,  $\frac{1}{2}$ – $\frac{3}{4}$  amb radius in length. Exine 2.0–3.0 microns thick distally and equatorially, thin proximally. Sculpture conate distally and equatorially with infrequent grana and verrucae; elements 0.5–2.0 microns high 0.5–1.5 microns in basal diameter, spaced 1.0–3.0 microns apart. Proximal sculpture of minute coni and grana, less than 1.0 micron in height and basal diameter; strongest at pole, becoming faint or absent towards the edge of the contact faces, which are delimited by abrupt ending of stronger distal sculpture, and proximal thinning of exine. Equatorial diameter 34.0 (40.0) 51.0 microns.

*Holotype*.—Slide S. 1254 : 37.0, 100.1. *Description*.—Spores trilete. Amb subcircular. Laesurae simple, sinuous, with narrow folds;  $\frac{3}{4}$  amb radius in length. Distal and equatorial sculpture of coni, with a few grana, 1.0–1.5 microns high, 1.0–1.5 microns in basal diameter. Proximally, minute coni and grana, less than 1.0 micron in height and basal diameter; strongest around pole, becoming reduced until exine is smooth at edge of contact faces. Exine 2.5 microns thick. Equatorial diameter 50.0 microns.

*Type locality*.—G.S.Q. D.R.D. No. 6 at 735 ft. 1 in. Precipice Sandstone, Surat Basin, Queensland.

*Remarks*.—This species is assigned to *Apiculatisporis* Potonié & Kremp, 1956 on the basis of its dominantly conate ornament, which is present in reduced form proximally.

*Comparison*.—*Apiculatisporis taroomensis* sp. nov. differs from *Apiculatisporis globosus* (Leschik) Playford & Dettmann, 1965 in having smaller sculptural elements and clearly reduced sculpture proximally. *Apiculatisporites variapiculatus* Danzé-Corsin & Laveine, 1963 lacks the clearly marked contact faces and distinctive proximal sculpture of *A. taroomensis*, and has longer laesurae and thinner exine.

*Distribution*.—Precipice Sandstone, lower Hutton Sandstone (this paper).

Genus *Anapiculatisporites* Potonié & Kremp, 1954

*Type species* (by original designation).—*Anapiculatisporites isselburgensis* Potonié & Kremp, 1954.

*Anapiculatisporites dawsonensis* sp. nov.

Pl. 1, figs 9–11

*Diagnosis*.—Spores trilete. Amb circular to subquadrangular. Laesurae reaching nearly to equator, with lips up to 1.0 micron high, often indistinct. Exine 1.0–3.0 microns thick distally and equatorially, thinner proximally. Distal and equatorial sculpture of coni, with a few verrucae and fine spinae, some with confluent bases; elements 1.0–3.0 microns high (most less than 2.0 microns), 1.0–2.0 microns in basal diameter, spaced 1.0–5.0 microns apart. Contact faces smooth, occupying most of proximal face. Edge of contact faces marked by narrow, often indistinct ridges. Equatorial diameter 32.0 (42.0) 53.0 microns.

*Holotype*.—Slide S. 1223: 28.2, 96.0. *Description*.—Spore trilete. Amb irregularly subcircular. Laesurae simple, straight, reaching equator. Equatorially and distally conate; coni 1.0–2.5 microns high, 1.0–2.0 microns in basal diameter; a few elements with confluent bases. Proximal face smooth. Exine 1.5 microns thick. Equatorial diameter 47.0 microns.

*Type locality*.—G.S.Q. D.R.D. No. 6 at 310 ft. 2 in. Evergreen Formation, Surat Basin, Queensland.



*Remarks.*—When compressed in the equatorial plane specimens may appear cingulate, but this is thought to be due to the thickness of the exine, often associated with the curvaturae. Obliquely oriented specimens show that the species is acingulate.

*Comparison.*—*Anapiculatisporites dawsonensis* sp. nov. lacks the three proximal verrucae and cingulum of *Foraminisporis tribulosus* Playford & Dettmann, 1965 and the murornate proximal sculpture of *Foraminisporis caelatus* sp. nov. *Anaplanisporites stipulatus* Jansonius, 1962 is smaller than *A. dawsonensis*, with shorter laesurae and uniformly smaller sculpture. *Anapiculatisporites telephorus* (Pautsch) Klaus, 1960 has smaller contact areas, a more uniformly spinulate sculpture and sinuous laesurae. *Triletes bifurcatus* Couper, 1960 has smaller sculptural elements and bifurcate laesurae. Spores described as *Acanthotriletes* cf. *A. levidensis* Balme by Norris (1965) have more regularly spinose sculpture, and thin areas bordering the laesurae.

*Distribution.*—Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

*Anapiculatisporites pristidentatus* sp. nov.

Pl. 1, figs 12–14

*Diagnosis.*—Spores trilete. Amb circular to subcircular. Laesurae indistinct, usually short ( $\frac{1}{2}$  amb radius), sometimes extending to equator. Distal and equatorial sculpture of coni, mostly pointed or rounded, occasionally truncate, with expanded bases; subcircular to suboval in basal section, up to 7.0 microns high, 2.0–5.0 microns in basal diameter, spaced 2.0–8.0 microns apart. Proximal surface smooth, thin, often folded; folds may parallel the trilete mark, simulating thickened lips. Exine up to 1.0 micron thick. Equatorial diameter 32.0 (41.0) 50.0 microns.

*Holotype.*—Slide S. 1253: 44.0, 115.4.

*Description.*—Spore trilete. Amb subcircular. Laesurae simple, straight;  $\frac{1}{2}$  amb radius in length. Distally and equatorially conate; coni generally pointed, a few rounded or truncate, 3.0–5.0 microns high, 2.5–4.0 microns in basal diameter. Proximally smooth, with folds approximately parallel to the trilete mark. Exine 1.0 micron thick. Equatorial diameter 46.0 microns.

*Type locality.*—G.S.Q. D.R.D. No. 6 at 735 ft. 1 in. Precipice Sandstone, Surat Basin, Queensland.

*Remarks.*—Some specimens have elements that vary within the given size range; others bear elements of nearly uniform size.

*Comparison.*—*Anapiculatisporites pristidentatus* sp. nov. differs from *Anapiculatisporites dawsonensis* sp. nov. in its larger and more variably spaced sculptural elements, and from *Verrucosisporites walloonensis* de Jersey, 1959, in having larger and generally more pointed elements. *Anapiculatisporites cooksonae* Playford, 1965 has lipped laesurae, thicker exine, and

coalescent elements equatorially. *Selaginella* sp. cf. *S. setiger* Kara-Murza, 1960 is similar to *A. dawsonensis*, but has more baculum-like elements.

*Distribution.*—Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Baculatisporites* Thomson & Pflug, 1953

*Type Species* (by original designation).—*Baculatisporites primarius* (Wolff) Thomson & Pflug, 1953.

*Baculatisporites comaumensis* (Cookson)  
Potonié, 1956

*Distribution.*—This species has wide stratigraphical and geographical range, and is common in the Australian Mesozoic. Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Neoraistrickia* Potonié, 1956

*Type species* (by original designation).—*Neoraistrickia truncata* (Cookson) Potonié, 1956.

*Neoraistrickia elongata* sp. nov.

Pl. 2, figs 1–3

1966 *Verrucosisporites walloonensis* de Jersey in Hill, Playford, & Woods, p. j.18, pl. J 9, fig. 10.

*Diagnosis.*—Spores trilete. Amb subtriangular with straight to slightly convex sides and rounded apices. Laesurae straight, lipped; length greater than  $\frac{2}{3}$  amb radius; lips faintly to strongly thickened, up to 2.0 microns wide. Exine 1.5–3.0 microns thick, baculate. Bacula sparse proximally, closely spaced distally and equatorially; processes usually with slightly expanded, flatly truncate apices 2.0–3.0 microns high, approximately 1.0 micron in diameter, up to 5.0 microns apart; usually borne on low (less than 1.0 micron high), rounded, sometimes coalescent swellings up to 3.0 microns in diameter. Equatorial diameter 25.0 (31.0) 40.0 microns.

*Holotype.*—Slide R22.3 : 32.2, 104.6. *Description.*—Spore trilete. Amb subtriangular with slightly convex sides and rounded apices. Laesurae straight, lipped, length  $\frac{2}{3}$ – $\frac{5}{8}$  amb radius; lips 2.0 microns wide, with rounded terminations just beyond the laesurate extremities. Exine 2.0 microns thick, baculate; proximal bacula confined to interradian regions near laesurae. Bacula 1.5–2.5 microns high, 1.0–1.5 microns in diameter, 2.0–4.0 microns apart, sides slightly concave in optical section, apices squarely truncate; processes borne on slight, rounded basal swellings about 3.0 microns in diameter. Diameter: 40.0 microns.

*Type locality.*—G.S.Q. D.R.D. No. 6 at 681 ft. 0 in. Evergreen Formation, Surat Basin, Queensland.

*Comparison.*—The specimen figured by Hill, Playford, and Woods (1966, pl. JIX, fig. 10) as *Verrucosisporites walloonensis* de Jersey, 1959, is relatively thick walled (2.0 microns), bearing a predominantly baculate sculpture; bacula average 2.0



microns in height, vary from 0.5–1.5 microns in diameter, and are generally borne on low, rounded, basal swellings. The proximal surface is unclear, but one distinctly lipped laesura is visible and extends  $\frac{2}{3}$  of the distance to the equator. These characteristics allow confident assignment of the specimen to *Neoraistrickia elongata* sp. nov.; they do not agree with de Jersey's diagnosis of *V. walloonensis*. *N. elongata* is similar to the type species, *Neoraistrickia truncata* (Cookson) Potonié, 1956 but the latter possesses longer laesurae and stouter bacula.

*Distribution*.—Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

*Neoraistrickia taylorii* Playford & Dettmann, 1965

*Distribution*.—Rhaeto-Liassic of South Australia (Playford & Dettmann, 1965); Middle Triassic Moolayember Formation (de Jersey & Hamilton, 1967); Triassic of Tasmania (Playford, 1965). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Cadargasporites* de Jersey & Paten, 1964 *emend.*

*Type species* (by original designation).—*Cadargasporites baculatus* de Jersey & Paten, 1964 *emend.*

*Emended diagnosis*.—Spores trilete. Amb circular to convexly subtriangular; polar and equatorial diameters approximately equal. Exine sculptured except for a sharply defined contact area surrounding the laesurae. Sculpture variable, including granulate, verrucate, spinate, baculate, rugulate and reticulate elements. Exine two layered: intexine smooth, exoexine sculptured except for the contact area.

*Remarks*.—The generic diagnosis is emended to include a haptotypic structure: study of a large number of specimens has shown that although the contact area is not sculptured, the exoexine may be present as a thinner smooth or scabrate layer (e.g. *Cadargasporites baculatus* de Jersey & Paten, 1964 *emend.*; see pl. 2, fig. 4).

*Cadargasporites baculatus* de Jersey & Paten, 1964 *emend.*

Pl. 2, figs 4–6

1964 *Cadargasporites baculatus* de Jersey & Paten, p. 5, pl. 2, figs 5–7; pl. 3, figs 1–3.

1964 *Cadargasporites granulatus* de Jersey & Paten (*pars*), p. 5, pl. 3, figs 4, 7.

*Emended diagnosis*.—Spores trilete, circular to subcircular in polar and lateral aspects. Exine two layered. Intexine smooth, thin (0.5–1.0 micron thick), often detached from, and folded within, the exoexine. Exoexine thicker (1.0–2.5 microns thick), strongly sculptured, except in a clearly developed proximal contact area, where the exoexine is smooth and membranous; exoexinal sculpture of spinae, bacula, coni, and rarely, grana, up to 1.5 microns in basal diameter, 0.5 to 4.0 microns in height, and 0.5–5.0

microns apart; intervening surface smooth, or scabrate with a faint micro-reticulate pattern. Contact area, radius  $\frac{1}{2}$  to  $\frac{3}{4}$  amb radius, bearing a simple trilete mark in the intexine, around which folding of the exoexine often gives the appearance of lips; laesurae extend to, or almost to, boundary of area; outer margin of area defined by the abrupt appearance of the exoexinal ornament, accompanied by an increase in exoexine thickness; it is frequently the site of further folding. Equatorial diameter 37.0 (53.0) 98.0 microns.

*Remarks*.—The specific diagnosis has been emended to include forms with dominantly conate and granulate sculptural elements, separated by smooth or scabrate exine, which were formerly included in *Cadargasporites granulatus* de Jersey & Paten, 1964 (pl. 3, figs 4, 7). Specimens have been encountered transitional between these and the dominantly spinate and baculate forms. *C. granulatus* has been emended (below) and now excludes these forms.

*Comparison*.—The distinction between *C. baculatus* de Jersey & Paten, 1964 *emend.* and *C. granulatus* de Jersey & Paten, 1964 *emend.* is discussed under the latter species. *Cadargasporites senectus* de Jersey & Hamilton, 1967 has a much finer sculpture of coni, grana, and microrugulae. *Apiculatisporites taroomensis* sp. nov. is sculptured proximally and has a single layered exine; also its sculptural elements are restricted to coni, grana and verrucae.

*Distribution*.—Precipice Sandstone, Evergreen Formation, basal Hutton Sandstone, Surat Basin (de Jersey & Paten, 1964; Paten, 1967). Precipice Sandstone, Evergreen Formation (this paper).

*Cadargasporites granulatus* de Jersey & Paten, 1964 *emend.*

Pl. 2, figs 7–9

1964 *Cadargasporites granulatus* de Jersey & Paten, (*pars*), p. 5, pl. 3, figs 5, 6.

*Emended diagnosis*.—Spores trilete. Circular to subcircular in polar and equatorial aspects. Exine 1.5–2.0 microns thick, two-layered, individual layers seldom discernible. Proximal contact area clearly developed, radius  $\frac{1}{2}$ – $\frac{3}{4}$  amb radius; bearing a simple trilete mark with laesurae extending to contact area margins; area generally circular in outline, sometimes trilobed, with interradian areas expanded outwards; bounded by a low rounded murus, 0.5 microns wide, or by an incomplete line of coalesced grana. Distal sculpture varies from an imperfect reticulum of low, narrow muri (approximately 0.25 micron wide) surmounted by grana, to a pattern of more discrete elements with some interconnecting muri. Elements dominantly grana, with some coni and hair-like elements, up to 2.0 microns apart, maximum basal diameter 1.0 micron, maximum height 2.0 microns (usually 0.5–1.0 micron). Sculpture reduced proximally, reticulum less pronounced or absent. Equatorial diameter 37.0 (47.0) 58.0 microns.



*Remarks.*—Re-examination of the holotype of *Cadargasporites granulatus* de Jersey & Paten, 1964 (p. 6, pl. 3, figs 5, 6) has shown that it has the characters of the emended diagnosis of the species; a specimen illustrated as *C. granulatus* de Jersey & Paten, 1964 (pl. 3, figs 4–7) is now assigned to *C. baculatus* de Jersey & Paten, 1964 *emend.* as the sculptural elements are separated by scabrate exine. The muri are characteristic of the species; they are low and narrow, and vary in number from relatively few, joining a minority of the elements, to many, forming an imperfect reticulum.

*Comparison.*—The presence of muri between the sculptural elements distinguishes *Cadargasporites granulatus* de Jersey & Paten, 1964 *emend.* from *C. baculatus* de Jersey & Paten, 1964 *emend.* Although there is an overlap in the size of the elements of the two species, those of *C. baculatus* are generally larger and more widely spaced. In *C. granulatus* the smooth contact area is often delimited by a narrow ridge or coalesced grana; the lips are low, and the two layers of exine closely appressed, whereas in *C. baculatus* the two layers are often seen separated, and the exoexine is often wrinkled. *Cadargasporites reticulatus* de Jersey & Paten, 1964 is more comprehensively reticulate than *C. granulatus*, with higher muri and a wider mesh. *Cadargasporites senectus* de Jersey & Hamilton, 1967 is distinct in having a finer, more varied ornament, and higher lips.

*Distribution.*—Evergreen Formation, Surat Basin (de Jersey & Paten, 1964). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

*Cadargasporites reticulatus* de Jersey & Paten, 1964  
Pl. 3, figs 3–5

*Remarks.*—The species has a two layered exine. The surface of the exoexine between the muri is scabrate or very finely granulate.

*Distribution.*—Evergreen Formation, Surat Basin (de Jersey & Paten, 1964; Paten, 1967). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

*Cadargasporites verrucosus* sp. nov.

Pl. 2, figs 10–13; pl. 3, figs 1, 2

*Diagnosis.*—Spores trilete. Amb subcircular to convexly subtriangular. Exine two layered. Contact area thin, smooth, two layered; extending to or nearly to equator. Laesurae straight, simple, or with low, narrow lips (less than 1.0 micron high), sometimes with a slight wrinkling of the adjacent exoexine. Margin of contact area marked by abrupt ending of distal ornament, and thinning of exoexine proximally. Sculptured distally with verrucae and a few grana; sculpture reaching equator or extending just onto proximal surface, mainly in the radial positions. Verrucae spaced 0.5–2.0 microns apart, irregularly polygonal to subcircular in basal section, with a low, usually rounded profile; 1.4–4.0 microns in height and in basal diameter. Intexine smooth, approximately

0.5 micron thick. Intexine often folded independently of exoexine. Equatorial diameter 21.0 (29.0) 37.0 microns.

*Holotype.*—Slide R27/3 : 42.1, 86.2.

*Description.*—Spore trilete. Amb subcircular. Contact area smooth. Laesurae simple, straight, reaching nearly to equator. Sculptured distally and equatorially with verrucae and a few grana; elements of variable size; verrucae 1.0–2.5 microns high, 1.0–4.0 basal diameter. Exoexine scabrate between elements, approximately 1.0 micron thick. Intexine very thin, smooth, slightly pulled away from exoexine, with a few, narrow folds. Equatorial diameter 29.0 microns.

*Type locality.*—G.S.Q. D.R.D. No. 6 at 713 ft. 0 in.; Evergreen Formation, Surat Basin, Queensland.

*Remarks.*—The two layers of exine have been frequently observed separated, the intexine folded independently of, and more frequently than, the exoexine. Verrucae on individual specimens may be of uniform or variable size. No lateral compressions have been seen. The differentiation of contact area and ornament at or near the equator seems to be a strong control as a plane of flattening. Study of specimens flattened in or near the equatorial plane indicates that the distal surface is strongly arched, the proximal surface less so (also see tetrad, pl. 3, fig. 2).

*Comparison.*—This species is assigned to *Cadargasporites* de Jersey & Paten, 1964 *emend.* because of its thin, smooth contact area, two layered exine and verrucate ornament. It is distinct from other species assigned to the genus in its small size and verrucate exine. It has a consistently wider contact area than other species of *Cadargasporites* except *Cadargasporites* sp. (de Jersey & Hamilton, 1967, p. 9, pl. 4, figs 9, 10), which has rugulate ornament. It is distinguished from species of *Grumosporites* Smith & Butterworth, 1967 in having a less regularly detached and deformed intexine, thinner exoexine, and a smooth contact area. *Mathesisporites tumulosus* Döring, 1965 and *Mathesisporites plurituberosus* Döring, 1965 are smooth proximally, but have larger sculptural elements than *C. verrucosus* and their exine appears to be one-layered.

*Distribution.*—Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Infraturma MURORNATI Potonié & Kremp, 1954

Genus *Foveosporites* Balme, 1957

*Type species* (by original designation).—*Foveosporites canalis* Balme, 1957.

*Foveosporites moretonensis* de Jersey, 1964

*Distribution.*—Upper Triassic Bundamba Group, Queensland (de Jersey, 1964). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).



*Foveosporites* sp.

Pl. 3, fig. 6

**Description.**—Spores trilete. Amb circular to convexly subtriangular. Laesurae simple, straight,  $\frac{1}{2}$ – $\frac{2}{3}$  amb radius in length. Sculpture of very fine pits and short channels 0.5–1.0 micron in diameter, 0.5–1.0 micron apart; sculpture reduced proximally. Exine thin, less than 1.0 micron thick. Equatorial diameter (3 specimens) 23.0, 30.0, 34.30 microns.

**Remarks.**—The specimens differ from *Foveosporites moretonensis* de Jersey, 1964 in having finer, more closely spaced sculptural elements and simple laesurae.

**Distribution.**—Precipice Sandstone, Evergreen Formation (this paper).

Genus *Lycopodiumsporites* Thiergart ex Delcourt & Sprumont, 1955

**Type Species** (by subsequent designation of Delcourt & Sprumont, 1955, p. 31).—*Lycopodiumsporites agathoecus* (Potonié) Thiergart, 1938.

*Lycopodiumsporites austroclavatidites* (Cookson) Potonié, 1956

Pl. 3, figs 7, 8

**Distribution.**—Widely distributed in Jurassic and Cretaceous sediments. Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

*Lycopodiumsporites rosewoodensis* (de Jersey) de Jersey, 1963

Pl. 3, figs 9, 10

1959 *Lycopodium rosewoodensis* de Jersey-p. 3, pl. 1, figs 5, 6.

1959 *Lycopodium triangularis* de Jersey, p. 3, pl. 1, fig. 7.

1963 *Lycopodiumsporites rosewoodensis* (de Jersey) de Jersey, p. 4, pl. 1, fig. 3.

1964 *Lycopodiumsporites rosewoodensis* de Jersey; de Jersey & Paten, p. 2, pl. 1, fig. 5.

**Restated diagnosis.**—Spores trilete. Amb triangular to sub-circular. Laesurae straight, narrow, often indistinct, reaching to, or nearly to, equator. Sculpture of a low reticulum distally and equatorially, which may partly extend onto the proximal face; proximal surface otherwise smooth. Lumina pentagonal or hexagonal, infrequently polygonal, maximum diameter 3.0–8.0 microns; muri up to 1.0 micron wide, 0.5–1.5 microns high, highest where muri intersect. Equatorial diameter 24.0 (32.0) 38.0 microns.

**Remarks and comparison.**—*Lycopodium triangularis* de Jersey, 1959 and *L. rosewoodensis* de Jersey, 1959 were originally differentiated on equatorial outline, the former having a triangular amb, the latter, a circular amb; however, study of more specimens shows a complete gradation between the two types. *Lycopodiumsporites rosewoodensis* (de Jersey) de Jersey, 1963 differs from *Lycopodiumsporites austroclavatidites* (Cookson) Potonié, 1956 in having lower, narrower muri and narrower indistinct laesurae.

The specimen figured as *L. clavatooides* Couper, 1958 by Levet-Carette (1964, pl. 18, fig. 15) closely resembles *L. rosewoodensis*.

**Distribution.**—Walloon Coal Measures, Queensland (de Jersey, 1959); Marburg Sandstone, Queensland (de Jersey, 1963); Jurassic of the Surat Basin, Queensland (de Jersey & Paten, 1964; Paten, 1967); Razorback Beds, Mount Morgan, Queensland (Playford & Cornelius, 1967). Precipice Sandstone, Evergreen Formation lower Hutton Sandstone (this paper).

*Lycopodiumsporites semimuris* (Danzé-Corsin & Laveine, 1963) comb. nov.

Pl. 3, fig. 11

1963 *Lycopodiumsporites semimuris* Danzé-Corsin & Laveine in Briche, Danzé-Corsin, & Laveine, p. 79, pl. 6, figs 15-17.

1965 *Lycopodiumsporites semimuris* Danzé-Corsin & Laveine; McGregor, p. 16, pl. 3, figs 46, 49, 50.

**Description.**—Spores trilete. Amb convexly subtriangular. Laesurae slightly sinuous, less than 1.0 micron wide, reaching to equator. Exine 1.0–1.5 microns thick. Proximal surface smooth, rarely with sparse granulae and rugulae (up to 9.0 microns long, 0.5 micron wide). Distal and equatorial surfaces imperfectly reticulate; muri up to 4.5 microns high, 0.5–1.0 micron wide, tapering in optical section, curved or zig-zag in polar view, irregularly disposed up to 4.0 microns apart, often interconnected, but rarely enclosing distinct lumina. Equatorial diameter 28.0 (32.0) 43.0 microns.

**Remarks.**—Danzé-Corsin & Laveine (in Briche et al., 1963, p. 79) contravened Article 73 of the International Code of Botanical Nomenclature in altering the spelling of *Lycopodiumsporites* Thiergart ex Delcourt & Sprumont, 1955 (cf. Playford, 1965, p. 176). It is thought that McGregor's (1965, p. 16) use of the correct generic designation was not formally intended, since he did not cite the name as a new combination.

**Comparison.**—This form is distinctive in its possession of an imperfect distal reticulum, which contrasts with the perfect reticulum of most other species of the genus. *Lycopodiumsporites semireticulatus* Burger, 1966 is similar in general form, but has considerably lower muri (1.0–1.5 microns high).

**Distribution.**—Rhaetic, Lower and Middle Jurassic of France (Briche et al., 1963; Levet-Carette, 1964 a, b.); Lower Jurassic of Canada (McGregor, 1965). Precipice Sandstone, Evergreen Formation (this paper).

Genus *Duplexisporites* Deák emend.

Playford &amp; Dettmann, 1965

**Type species** (by original designation).—*Duplexisporites generalis* Deák, 1962.



*Duplexisporites gyratus* Playford & Dettman, 1965

Pl. 3, fig. 12

*Distribution*.—Rhaeto-Liassic of South Australia (Playford & Dettmann, 1965); Triassic and Lower Jurassic of Queensland (de Jersey, 1964; de Jersey & Paten, 1964; Playford & Cornelius, 1967; Paten, 1967; de Jersey & Hamilton, 1967). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Staplinisporites* Pocock, 1962

*Type species* (by original designation).—*Staplinisporites caminus* (Balme) Pocock, 1962.

*Staplinisporites caminus* (Balme) Pocock, 1962

Pl. 3, fig. 14

*Distribution*.—Upper Jurassic of Western Australia (Balme, 1957); Lower Cretaceous of south-eastern Australia (Dettmann, 1963); upper Evergreen Formation, lower Hutton Sandstone (de Jersey & Paten, 1964); upper Evergreen Formation (Paten, 1967). Evergreen Formation, lower Hutton Sandstone (this paper).

*Staplinisporites* sp. cf. *S. caminus* (Balme) Pocock, 1962

Pl. 3, fig. 13

1966 *Staplinisporites* cf. *caminus* (Balme) Pocock in Hill, Playford, & Woods, p. j.18, pl. J 9, fig. 16.

*Description*.—Spores trilete. Amb convexly subtriangular to subcircular. Laesurae straight to weakly sinuous, reaching equator, with low (less than 1.0 micron high) lips. Distal equatorial area bearing low, narrow (1.0–2.0 microns wide), closely spaced muri, radially arranged and often anastomosing; muri reach from equator to a narrow (1.0–2.0 microns wide) ridge, concentric with, and about  $\frac{2}{3}$  radius of, amb. Distal polar exine within ridge with narrow (1.0 micron wide), low, sinuous rugulae, sometimes enclosing lumina. A slight distal polar thickening is present on two specimens. Equatorial diameter (6 specimens) 38.0 (42.0) 48.0 microns.

*Comparison*.—These specimens differ from *Staplinisporites caminus* (Balme) Pocock, 1962 in having rugulate distal ornament, more closely spaced, and sometimes anastomosing radial muri; furthermore, they lack a well defined distal boss. The forms closely resemble an illustration of *Triangulatisporites mathurii* Srivastava, 1966 (p. 91, pl. 3, fig. 5); the figure is not clear enough to allow close comparison, but it is possible that Srivastava's description of the equatorial structure as a "flange" is incorrect, since the structure appears to resemble that of *Staplinisporites* sp. cf. *S. caminus*.

*Distribution*.—Upper Evergreen Formation, lower Hutton Sandstone (this paper).

Subturma

ZONOTRILETES Waltz, 1935

Infraturma

AURICULATI Schopf *emend.*  
Dettmann, 1963

Genus *Trilobosporites* Pant ex Potonié, 1956

*Type species* (by subsequent designation of Potonié, 1956, p. 55).—*Trilobosporites hannonicus* (Delcourt & Sprumont) Potonié, 1956.

*Discussion*.—Delcourt *et al.* (1963) discussed the genus and refigured the type specimen. The authors do not agree with Döring's (1965) attempt to widen the genus to include smooth forms, which may be assigned to *Matonisporites* Couper *emend.* Dettmann, 1963.

*Trilobosporites* Pant ex Potonié, 1956 has been recorded mainly from Lower Cretaceous and younger strata. In Britain, it is a good indicator for the Lower Cretaceous (Dr. M. Muir, pers. comm). There are several reports of the genus from the Wealden of Europe; and Pocock (1962) recorded it from the Lower Cretaceous of Canada. Dettmann (1963) recorded four species of *Trilobosporites* from the Lower Cretaceous of south-eastern Australia. Sah & Jain (1965) recorded *Trilobosporites* from the Rajmahal Hills, India, giving an age of probably Middle-Upper Jurassic. The Surat Basin occurrence extends the range of the genus into the Lower Jurassic.

*Trilobosporites antiquus* sp. nov.

Pl. 3, fig. 15; pl. 4, fig. 1

1964 *Matonisporites* sp. de Jersey & Paten, p. 3, pl. 1, figs 11, 12.

1966 *Matonisporites* sp. in Hill, Playford, & Woods, p. j. 20, pl. J 10, figs 1, 2.

*Diagnosis*.—Spores trilete, valvate. Amb subtriangular, sides concave to convex, apices rounded-lobate. Laesurae reaching to valvae; flanked by low thickened lips, sometimes indistinct, up to 11.0 microns wide; laesurae straight, often forked towards the equator. Exine one-layered, thickened radially to form valvae; here the exine is 2.0–9.5 microns thick, interradially 2.0–5.5 microns thick. Sculpture of valvae varies from shallow depressions to sharply defined subcircular foveolae 1.0–5.5 microns in diameter; walls of foveolae sloping rather than vertical in optical section. Exine smooth to scabrate distally; proximal surface punctate, either comprehensively or only along laesurae. Equatorial diameter 38.0 (60.0) 78.0 microns.

*Holotype*.—Slide S. 1243 : 38.9, 116.0.

*Description*.—Spore trilete, valvate. Amb subtriangular, sides nearly straight, apices lobate. Laesurae reach to valvae, with broad, low, indistinct, thickened lips, approximately 11.0 microns wide. Exine 2.0 microns thick sculptured with foveolae 2.0–5.0 microns in diameter. Exine smooth distally and equatorially, comprehensively punctate proximally. Equatorial diameter 78.0 microns.



*Type locality*.—G.S.Q. D.R.D. No. 6 at 266 ft. 2 inches. Evergreen Formation, Surat Basin, Queensland.

*Remarks and Comparison*.—*Trilobosporites antiquus* sp. nov. is assigned to *Trilobosporites* Pant ex Potonié, 1956 because of its sculptured valvae, although it lacks the comprehensively sculptured exine of the type species (see Potonié, 1956, p. 55; Delcourt *et al.*, 1963, p. 288). The species shows wide variation in the strength of the sculpture of the valvae, and minor variation in exine thickness and development of lips; however, there appears to be continuous variation and there are no good criteria for further differentiation. The sculpture of the valvae varies from a few shallow depressions to an imperfectly reticulate pattern. The foveolae are most strongly developed in specimens with the strongest valvae, giving these forms a more irregular outline. The greater part of each valva is distal.

The species is distinct from others within the genus in its distally smooth, proximally punctate exine and foveolate valvae.

*Distribution*.—Upper Evergreen Formation, basal Hutton Sandstone (de Jersey & Paten, 1964). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Ischyosporites* Balme, 1957

*Type Species* (by original designation).—*Ischyosporites crateris* Balme, 1957.

*Ischyosporites marburgensis* de Jersey, 1963

Pl. 3, fig. 16

*Distribution*.—Jurassic of Queensland (de Jersey, 1964; de Jersey & Paten, 1964; Paten, 1967); Rhaeto-Liassic of South Australia (Playford & Dettmann, 1965). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Infraturma TRICRASSATI Dettmann, 1963

Genus *Gleicheniidites* Ross ex Delcourt & Sprumont *emend.* Dettmann, 1963

*Type species* (by monotypy).—*Gleicheniidites senonicus* Ross, 1949.

*Gleicheniidites senonicus* Ross, 1949

Pl. 4, fig. 2

*Distribution*.—Widely recorded from Jurassic, Cretaceous, and Tertiary sediments. Evergreen Formation (this paper).

Genus *Camarozonosporites* Pant ex Potonié *emend.* Klaus, 1960

*Type species* (by subsequent designation of Potonié, 1956, p. 65).—*Camarozonosporites cretaceus* (Weyland & Krieger) Potonié, 1956.

*Camarozonosporites rudis* (Leschik) Klaus, 1960

Pl. 4, figs 3–5

1955 *Verrucosisporites rudis* Leschik, p. 15, pl. 1, fig. 15.

1960 *Camarozonosporites rudis* (Leschik) Klaus, p. 136, pl. 29, figs 12, 14, 16.

1966 *Camarozonosporites* sp. in Hill, Playford, & Woods, p. j.18, pl. J9, fig. 17.

1966 non *Camarozonosporites rudis* (Leschik) Klaus; Hedlund, p. 17, pl. 3, fig. 3.

1967 *Camarozonosporites* sp. Playford & Cornelius, pp. 90, 91, figs 6, 7.

*Description*.—Spores trilete, interrally crassate. Amb roundly subtriangular. Laesurae distinct, sometimes gaping (0.5 micron wide), reaching almost to the equator; bordered by wide (4.0–6.0 microns), strongly thickened lips, parallel-sided or tapering slightly towards the equator, with broadly sinuous margins. Exine laevigate proximally; thickened equatorially to form distinct interrally crassitudes (exine 1.0–2.0 microns thick radially, 1.5–3.5 microns interrally); arched distally with sculpture of broad (1.0–3.0 microns wide), irregularly sinuous rugulae, 0.5–2.0 microns apart. Equatorial diameter 29.0 (37.0) 48.0 microns.

*Remarks*.—Professor W. Klaus (pers. comm.) has studied photomicrographs of the Queensland specimens and supports their assignment to *Camarozonosporites rudis* (Leschik) Klaus, 1960.

*Distribution*.—Keuper of Switzerland (Leschik, 1955); Norian, Rhaetic, and Liassic of Germany and Austria (Klaus, 1960, and pers. comm.); Upper Rhaetic and Lias  $\alpha$  of Germany (Mädler, 1964); Norian and Rhaetic of central Europe (Schulz, 1966, 1967); Upper Triassic of Canada (McGregor, 1965); Lower Jurassic Razorback Beds, Queensland (Playford & Cornelius, 1967). Precipice Sandstone, Evergreen Formation (this paper).

Infraturma CINGULATI Potonié & Klaus *emend.* Dettmann, 1963

Genus *Cingutritetes* Pierce *emend.* Dettmann, 1963

*Type species* (by original designation).—*Cingutritetes congruens* Pierce, 1961.

*Cingutritetes* sp. cf. *C. clavus* (Balme) Dettmann, 1963

Pl. 4, figs 6, 7

*Description*.—Spores trilete, cingulate. Amb circular to convexly subtriangular. Laesurae straight, length greater than  $\frac{1}{2}$  radius spore body; lips 2.0–5.0 microns wide. Cingulum 2.0–6.0 microns wide; generally of uniform width, but sometimes thickened radially; clearly to indistinctly radially striate. Proximal and distal surfaces scabrate, rarely with a slight distal polar thickening, 8.0–20.0 microns in diameter. Equatorial diameter 30.0 (37.0) 46.0 microns.

*Remarks*. The distal thickening of *Cingutritetes clavus* (Balme) Dettmann, 1963, is seldom clearly delimited in these specimens, and the breakdown to



verrucae and grana in corroded specimens (Dettmann, 1963, p. 69) has not been observed. Spores illustrated as *Cingutritetes* sp. by Playford & Cornelius (1967, pl. 1, figs 13, 14) are smaller, but otherwise appear to be identical with those described above.

*Distribution*.—Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Foraminisporis* Krutzsch, 1959

*Type species* (by original designation).—*Formainisporis foraminis* Krutzsch, 1959.

*Remarks*.—As originally defined, *Foraminisporis* Krutzsch, 1959 was intended for azonate spores, with distal coni and a foraminate proximal surface bearing interradian groups of "wart-like processes". Dettmann (1963) referred narrowly cingulate forms to the genus, noting that they did not conform strictly to Krutzsch's original definition; furthermore, two of her species, *Foraminisporis wonthaggiensis* (Cookson & Dettmann) Dettmann, 1963 and *F. asymmetricus* (Cookson & Dettmann), Dettmann, 1963 lack interradian grouping of proximal ornament, and the exine of the latter is non-punctate. However, it is obvious that Dettmann's species, together with *F. tribulosus* Playford & Dettmann, 1965, form a distinctive morphographic grouping which can be compared closely with the illustrations of the type (Krutzsch, 1959, pl. 19, figs 203–206) of *Foraminisporis*, Krutzsch's generic diagnosis notwithstanding.

The following features characterise at least the Australian representatives of the genus:—

- (1) Amb irregularly subcircular to subquadrangular.
- (2) Lipped laesurae extending to the equator.
- (3) Narrow sculptured cingulum.
- (4) Conate, granulate, or verrucate distal and equatorial sculpture.
- (5) Proximal sculptural elements reduced, or markedly different from those of the distal surface.

The possession of a cingulum is the main difference between Krutzsch's and Dettmann's concepts of the genus. This feature was apparent only after a critical examination of specimens in oblique orientations (Dettmann, 1963, p. 71). The distinction between forms with a weakly developed equatorial thickening and those with a comprehensive thickening of the distal hemisphere is so slight that the genus is here considered to include both types, and to agree in other respects with the above characters. Formal emendation of the genus must await re-examination of the type material.

*Foraminisporis caelatus* sp. nov.

Pl. 4, figs 12, 13

*Diagnosis*.—Spores trilete. Amb irregularly subcircular to subquadrangular. Laesurae often indistinct, reaching equator, with raised (1.0 micron high)

lips. Exine 1.5–3.0 microns thick, apparently thickened both distally and equatorially. Distal and equatorial sculpture of coni, with a few verrucae; elements 1.0–3.0 microns in height and in basal diameter, some with expanded bases which infrequently coalesce. Proximal sculpture of low rugulae, some intersecting to form an imperfect reticulum; rugulae 1.0–5.0 microns wide; lumina irregularly subcircular, 2.0–4.0 microns in diameter. Equatorial diameter 44.0 (50.0) 53.0 microns.

*Holotype*.—Slide S. 1024: 37.4, 105.4. *Description*.—Spore trilete. Amb subcircular. Laesurae indistinct, slightly gaping. Exine 1.5 microns thick. Distally and equatorially conate; coni sharply pointed, a few more rounded; 1.0–1.5 microns in height and basal diameter; a few with slightly expanded and coalescent bases. Proximal ornament of low rugulae, forming an imperfect reticulum. Rugulae 1.0–4.0 microns wide, lumina subcircular, 3.0–4.0 microns in diameter. Equatorial diameter 48.0 microns.

*Type locality*.—G.S.Q. D.R.D. No. 12 at 400 ft 5 in. Evergreen Formation, Surat Basin, Queensland.

*Remarks and comparison*.—*Foraminisporis caelatus* sp. nov. is not considered cingulate, although no obliquely orientated specimens have been encountered to allow critical examination of equatorial structure. It is distinguished from other species of the genus by its murornate proximal sculpture. *Anapiculatisporites dawsonensis* sp. nov. is similar in general appearance, but lacks proximal sculpture.

*Distribution*.—Precipice Sandstone, lower Evergreen Formation (this paper).

*Foraminisporis tribulosus* Playford & Dettmann, 1965

Pl. 4, fig. 10

*Remarks*.—Only one specimen was found, occurring in the lowest sample of D.R.D. No. 6.

*Distribution*.—Rhaeto-Liassic of South Australia (Playford & Dettmann, 1965). Lower Precipice Sandstone, Surat Basin (de Jersey & Paten, 1964; this paper).

Genus *Nevesisporites* de Jersey & Paten, 1964

*Type species* (by original designation).—*Nevesisporites vallatus* de Jersey & Paten, 1964.

*Nevesisporites vallatus* de Jersey & Paten, 1964

Pl. 4, fig. 11

*Description*.—Spores trilete, cingulate. Amb circular to convexly subtriangular. Laesurae straight, often forked distally, simple or slightly lipped, reaching to spore body margin. Cingulum smooth, 2.0–4.0 microns wide, occasionally with a slightly irregular margin. Distal exine smooth. Proximal sculpture of grana, verrucae and rugulae up to 3.0 microns (mostly 0.5–1.5 microns) in maximum basal measurement; elements variably disposed, but generally with closely



spaced, often partly coalescing, rugulae along the laesurate margins, set obliquely or at right angles to the laesurae. Equatorial diameter 33.0 (41.0) 51.0 microns.

*Remarks.*—The above description agrees with de Jersey & Paten's (1964, p. 8) original diagnosis, except that no baculate elements were observed.

*Distribution.*—Evergreen Formation and Hutton Sandstone, Surat Basin (de Jersey & Paten, 1964; Paten 1967). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Antulsporites* Archangelsky & Gamero, 1966b

1966a *Heliosporites* Archangelsky & Gamero, p. 203.

*Type Species* (by original designation).—*Antulsporites baculatus* (Archangelsky & Gamero) Archangelsky & Gamero, 1966b.

*Discussion.*—The genus was first designated *Heliosporites*, but this name was pre-occupied (*Heliosporites* Schulz, 1962, p. 311). Later, Archangelsky & Gamero (1966b, p. 369) substituted the present name.

*Antulsporites* Archangelsky & Gamero 1966b is distinguished by its radially striate cingulum together with a proximally smooth, distally sculptured (baculate, spinulate or verrucate) exine. It differs in sculptural detail from the cingulate genera *Cingulitrites* Pierce *emend.* Dettmann, 1963, *Nevesisporites* de Jersey & Paten, 1964, and *Cingulatisporites* Thomson, 1953.

*Antulsporites varigranulatus* (Levet-Carette, 1964a),  
comb. nov. et *emend.*

Pl. 4, figs 8–9

1959 *Sphagnumsporites clavus* (Balme) de Jersey, p. 348,  
pl. 1, fig. 2.

1964a *Lycopodiacidisporites varigranulatus* Levet-Carette,  
p. 110, pl. 18, fig. 11.

*Emended diagnosis.*—Spores trilete, cingulate. Amb roundly subtriangular. Laesurae straight to slightly sinuous, length  $\frac{2}{3}$ – $\frac{3}{4}$  spore body radius; lips slightly to strongly thickened, usually broad (7.0 microns), tapering slightly towards equator. Cingulum of uniform width (1.5–3.0 microns), with smooth to crenulate margin; surface usually smooth, sometimes fluted, giving a radially striate appearance. Proximal exine thin, usually smooth, rarely with sparse verrucae and grana, 0.5–2.0 microns in diameter. Distal sculpture predominantly verrucate, with rare grana; verrucae low, rounded in profile, irregularly polygonal to subcircular in basal outline, diameter 0.5–5.0 microns, usually closely spaced (up to 5.0 microns apart, average 0.5–1.0 micron). Equatorial diameter 25.0 (33.0) 43.0 microns.

*Remarks.*—Levet-Carette's (1964a, p. 110) specific diagnosis does not mention a cingulum and

defines the distal sculpture as granulate. However, the illustration (Levet-Carette, 1964a, pl. 18, fig. 11) shows clearly a continuous band of equatorial thickening; moreover, direct measurement from the photograph suggests that the basal diameter of the sculptural element is greater than the quoted value of 1.0 micron. The presence of a cingulum makes Levet-Carette's generic assignment incorrect, since *Lycopodiacidisporites* Danzé-Corsin & Laveine, 1963 (a synonym of *Lycopodiacidites* Couper *emend.* Potonié, 1956) is acingulate. The species is placed in the genus *Antulsporites* Archangelsky & Gamero, 1966 because of its cingulum, distal verrucae, and smooth or finely sculptured proximal surface.

de Jersey (1959) figured a specimen illustrating his new combination *Sphagnumsporites clavus* (Balme) de Jersey, 1959 (p. 348, pl. 1, fig. 2); this specimen does not conform with Balme's (1957, p. 16) original definition of the species, in that it is cingulate and bears a comprehensive distal sculpture; it does conform with the emended diagnosis of *Antulsporites varigranulatus* (Levet-Carette, 1964a) comb. nov. et *emend.* Contrary to Dettmann (1963, p. 69), it is thought that de Jersey's specimen is genuinely verrucate and not a corroded example of *Cingulitrites clavus* (Balme) Dettmann, 1963.

*Comparison.*—*Sphagnum subflavum* Bolkhovitina, 1959 lacks the verrucate distal sculpture of *A. varigranulatus*. *Sphagnum regium* Drozhashchikh, 1961 is smaller than *A. varigranulatus*, with laesurae less than  $\frac{1}{2}$  spore radius enclosed within narrow, straight-sided lips which taper acutely to a point beyond the ends of the laesurae; moreover, the verrucae of the Russian form are sparser and more uniform. Reissinger (1950, p. 104 pl. 12, fig. 41) figured a specimen which bears close resemblance to *A. varigranulatus*; he suggested lycopod affinities for the form, but did not give a description. The illustration is not clear enough to warrant firm assignment of the specimen to *A. varigranulatus*. *A. varigranulatus* differs from the type species, *A. baculatus* (Archangelsky & Gamero) Archangelsky & Gamero, 1966, in having broader, more sharply tapering lips which do not extend onto the cingulum, verrucate as opposed to baculate-spinulate distal sculpture, and a smooth rather than finely granulate proximal surface. *Stenozonotriletes bimammatus* Naumova ex Bolkhovitina, 1953 is much smaller than *A. varigranulatus*; distribution of the verrucate sculpture of the Russian species is not reported, and thus closer comparison is impossible. *Verrucosisporites pulvinulatus* Manum, 1962 is irregular in equatorial outline, and lacks a well defined cingulum.

*Distribution.*—Jurassic Walloon Coal Measures, Queensland (de Jersey, 1959); Infraliassic (Rhaetic and Hettangian) of France (Levet-Carette, 1964a). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).



Genus *Annulispora* de Jersey, 1959

*Type Species* (by original designation).—*Annulispora folliculosa* (Rogalska) de Jersey, 1959.

*Annulispora folliculosa* (Rogalska) de Jersey, 1959

*Distribution*.—Liassic of Poland (Rogalska, 1954); Triassic and Jurassic of Queensland (de Jersey, 1959, 1962, 1963, 1964; de Jersey & Paten, 1964; Paten, 1967; Playford and Cornelius, 1967); Triassic of Tasmania (Playford, 1965). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

*Annulispora microannulata* de Jersey, 1962

*Distribution*.—Triassic and Jurassic of Queensland (de Jersey, 1962, 1963, 1964; de Jersey & Paten, 1964; Paten, 1967; Playford & Cornelius, 1967). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Polycingulatisporites* Simoncsics & Kedves  
*emend.* Playford & Dettmann, 1965

*Type Species* (by original designation).—*Polycingulatisporites circulus* Simoncsics & Kedves, 1961.

*Polycingulatisporites crenulatus* Playford & Dettmann, 1965

Pl. 5, fig. 2

*Remarks*.—The specimen figured by Schulz (1967, pl. 14, figs 10, 11) as *Neochomotriletes triangularis* (Bolkhovitina) Reinhardt, 1962 is very similar to *Polycingulatisporites crenulatus* Playford & Dettman, 1965, but no striation of the cingulum and distal ridges is indicated in Schulz's line drawing (1967, pl. 23, fig. 4)

*Distribution*.—Rhaeto-Liassic of South Australia (Playford & Dettman, 1965); Precipice Sandstone to Hutton Sandstone, ? Walloon Coal Measures, Surat Basin (de Jersey & Paten, 1964; Paten, 1967); Lower Jurassic Razorback Beds, Queensland (Playford & Cornelius, 1967). Precipice Sandstone, Evergreen Formation (this paper).

*Polycingulatisporites mooniensis* de Jersey & Paten, 1964

Pl. 5, fig. 1

*Remarks*.—The cingulum sometimes appears partially striate. The ridges may have crenulate margins, and they decrease in thickness towards the pole, so that the outer boundary is often more clearly defined than the inner one.

*Distribution*.—Precipice Sandstone and Lower Evergreen Formation, Surat Basin (de Jersey & Paten, 1964; Paten, 1967); Lower Jurassic Razorback Beds, Queensland (Playford & Cornelius, 1967). Precipice Sandstone, lower Evergreen Formation (this paper).

*Polycingulatisporites densatus* (de Jersey) Playford & Dettmann, 1965

*Distribution*.—Jurassic Walloon Coal Measures, Queensland (de Jersey, 1959); Rhaeto-Liassic of South Australia (Playford & Dettmann, 1965); Evergreen Formation, Surat Basin (Paten, 1967); Lower Jurassic Razorback Beds, Queensland (Playford & Cornelius, 1967). Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Contignisporites* Dettmann, 1963

*Type species* (by original designation).—*Contignisporites glebulentus* Dettmann, 1963.

*Discussion*.—The four specimens described below agree with Dettmann's generic diagnosis except that they are smooth proximally; proximally smooth specimens were assigned to the genus by Singh & Kumar (1966).

*Contignisporites* sp.

Pl. 5, figs 3, 4

*Description*.—Spores trilete, cingulate. Amb subtriangular. Cingulum smooth, 3.0–4.0 microns wide. Laesurae extend to edge of spore body; lips narrow, indistinct. Distal surface with 7–8 more or less parallel, sometimes bifurcating muri, arranged roughly perpendicular to one laesura. Muri undulating in longitudinal optical section, rounded in cross section, 2.5–4.0 microns wide, 2.0–4.0 microns high, spaced approximately 1.0 micron apart. Proximal surface smooth. Equatorial diameter (2 specimens): 40.0, 48.0 microns.

*Remarks*.—Only four specimens were found, from D.R.D. Nos. 1 and 6. This is the stratigraphically lowest record of the genus in Queensland. *Contignisporites cooksonii* (Balme) Dettmann, 1963 has been recorded from the upper Walloon Coal Measures of the Surat Basin (de Jersey & Paten, 1964).

*Comparison*.—The specimens are similar to *Contignisporites dunrobinensis* (Couper) Dettmann, 1963, except for lower muri and smaller overall size. *Contignisporites cooksonii* (Balme) Dettmann, 1963 has clear proximal sculpture and more widely spaced muri. *Contignisporites dettmannii* Singh & Kumar, 1966 and *Contignisporites psilatus* Singh & Kumar, 1966 have much broader cingula than the present form.

*Distribution*.—Upper Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Cingulatisporites* Thomson, 1953

*Type species* (by original designation).—*Cingulatisporites levispeciosus* Pflug, 1953.

*Cingulatisporites saevus* (Balme) de Jersey & Paten, 1964

*Remarks*.—Only one specimen was recorded. Archangelsky & Gamero (1966, p. 369) included



both *Cingulatisporites saevus* Balme, 1957 and *Cingulatisporites granulatus* de Jersey, 1959 as species of their new genus *Antulsporites* Archangelsky & Gamero, 1966. However, de Jersey & Paten (1964, p. 6, pl. 5, figs. 4, 5, 6) validly emended *C. saevus* Balme, 1957, including *C. granulatus* de Jersey, 1959 as a synonym. It is probable that the species thus circumscribed could be assigned to the genus *Antulsporites*, but as only one specimen was found no redescription or reassignment is made.

*Distribution.*—Upper Jurassic of Western Australia (Balme, 1957). Jurassic of Queensland: Walloon Coal Measures (de Jersey, 1959); Marburg Sandstone (de Jersey, 1963); uppermost Evergreen Formation to Blythesdale Group, Surat Basin (de Jersey & Paten, 1964). Lower Hutton Sandstone (this paper).

|               |                                            |
|---------------|--------------------------------------------|
| Turma         | MONOLETES Ibrahim, 1933                    |
| Suprasubturma | ACAVATITRILETES Dettmann, 1963             |
| Subturma      | AZONOMONOLETES Lubert, 1935                |
| Infraturma    | LAEVIGATOMONOLETI Dybová & Jachowicz, 1957 |

#### Genus *Punctatosporites* Ibrahim, 1933

*Type species* (by monotypy, after Schopf, Wilson, & Bentall, 1944 p. 37).—*Punctatosporites minutus* Ibrahim, 1933.

#### *Punctatosporites walkomi* de Jersey, 1962

*Distribution.*—Triassic of Queensland (de Jersey, 1962, 1964; de Jersey & Hamilton, 1967); Jurassic of Queensland (Paten, 1967); Triassic of Tasmania (Playford, 1965); Rhaeto-Liassic of South Australia (Playford & Dettmann, 1965). Precipice Sandstone Evergreen Formation, lower Hutton Sandstone (this paper).

|            |                                                           |
|------------|-----------------------------------------------------------|
| Anteturma  | POLLENITES Potonié, 1931                                  |
| Turma      | SACCITES Erdtman, 1947                                    |
| Subturma   | MONOSACCITES Chitaley <i>emend.</i> Potonié & Kremp, 1954 |
| Infraturma | SACCIZONATI Bhardwaj, 1957                                |

#### Genus *Tsugaepollenites* Potonié & Venitz *emend.*, Potonié, 1958

*Type species* (by subsequent designation of Potonié, 1958 p. 48).—*Tsugaepollenites igniculus* (Potonié) Potonié & Venitz, 1934.

#### *Tsugaepollenites* spp.

Pl. 5, figs 5–8

*Discussion.*—Balme (1957) described three species, subsequently assigned by Dettmann (1963) to *Tsugaepollenites* Potonié & Venitz *emend.* Potonié, 1958, which have been found to have world-wide distribution: *Tsugaepollenites segmentatus* (Balme) Dettmann, 1963, *T. dampieri* (Balme) Dettmann, 1963, and *T. trilobatus* (Balme) Dettmann, 1963. Specimens agreeing with Balme's original descriptions

have been found in the present study, but, when all forms assignable to the genus are considered, there appears to be a gradation from *T. segmentatus* through *T. dampieri* to *T. trilobatus*. As the present study is based on specimens within a restricted time range (at and just above the level of their first appearance in the Surat Basin), the three species are not merged, since it is likely that the three types become more clearly differentiated in younger sediments. Specimens of *T. trilobatus*, on which the sacchi are not completely divided and the central body is folded to a triangular shape, resemble some forms of *Inaperturopollenites turbatus* Balme, 1957.

*Affinities.*—Gamero (1965) and Townrow (1967) have recorded grains of *T. dampieri* and *T. trilobatus* associated with *Apterocladus lanceolatus* Archangelsky, and *Masculostrobilus warreni* Townrow, 1967 respectively; both plants are referred to ? Podocarpaceae.

*Distribution.*—The three species have world-wide distribution in Jurassic and Cretaceous sediments; they are widespread in the Australian Mesozoic and Tertiary: Jurassic to Eocene of Western Australia, Aptian–Albian of New Guinea (Balme, 1957); Upper Mesozoic of south-eastern Australia (Dettmann, 1963); Jurassic of Queensland–Walloon Coal Measures (de Jersey, 1959); Marburg Sandstone (de Jersey, 1963); upper Evergreen Formation to Blythesdale Group, Surat Basin (de Jersey & Paten, 1964; Paten, 1967). Upper Evergreen Formation, lower Hutton Sandstone (this paper).

#### Subturma DISACCITES Cookson, 1947

#### Genus *Alisporites* Daugherty, 1941

*Type Species* (by monotypy).—*Alisporites opii* Daugherty, 1941.

#### *Alisporites australis* de Jersey, 1962

*Distribution.*—Middle and Upper Triassic, and Lower Jurassic of Queensland (de Jersey, 1962, 1964; de Jersey & Hamilton, 1965, 1967; de Jersey & Paten, 1964; Playford & Cornelius, 1967; Rhaeto-Liassic of South Australia (Playford & Dettmann, 1965). Precipice Sandstone, Evergreen Formation (this paper).

*Alisporites* sp. cf. *A. grandis* (Cookson) Dettmann, 1963

Pl. 5, fig. 18

*Dimensions.*—Breadth: overall 54.0 (82.0) 114.0 microns; corpus 37.0 (52.0) 88.0 microns; saccus 18.0 (27.0) 37.0 microns. Length: corpus 48.0 (60.0) 71.0 microns; saccus 41.0 (61.0) 78.0 microns.

*Distribution.*—Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).



*Alisporites lowoodensis* de Jersey, 1963

Pl. 6, fig. 1

*Dimensions*.—Breadth: overall 44·0 (57·0) 71·0 microns; corpus 27·0 (39·0) 44·0 microns; saccus 14·0 (22·0) 39·0 microns. Length: corpus 27·0 (36·0) 51·0 microns; saccus 27·0 (38·0) 51·0 microns.

*Distribution*.—Queensland Jurassic: Marburg Sandstone (de Jersey, 1963); Evergreen Formation, Hutton Sandstone of the Surat Basin (de Jersey & Paten, 1964; Paten, 1967); Razorback Beds (Playford & Cornelius, 1967). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

*Alisporites* sp. cf. *A. similis* (Balme) Dettmann, 1963

Pl. 6, fig. 2

*Dimensions* (17 specimens).—Breadth: overall 37·0 (52·0) 61·0 microns; corpus 20·0 (30·0) 37·0 microns; saccus 17·0 (20·0) 24·0 microns. Length: corpus 27·0 (35·0) 42·0 microns; saccus 31·0 (36·0) 40·0 microns.

*Distribution*.—Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Podocarpidites* Cookson ex Couper, 1953

*Type species* (by subsequent designation of Couper, 1953, p. 35).—*Podocarpidites ellipticus* Cookson, 1947.

*Podocarpidites* sp. cf. *P. ellipticus* Cookson, 1947

Pl. 6, fig. 3

*Dimensions*.—Breadth: Overall 48·0 (62·0) 75·0 microns; corpus 31·0 (38·0) 51·0 microns; saccus 15·0 (24·0) 31·0 microns; Length: corpus 24·0 (40·0) 61·0 microns; saccus 34·0 (48·0) 65·0 microns.

*Distribution*.—Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Vitreisporites* Leschik emend. Jansonius, 1962

*Type species* (by original designation).—*Vitreisporites signatus* Leschik, 1955.

*Vitreisporites pallidus* (Reissinger) Nilsson, 1958

Pl. 6, figs 4–6

*Dimensions*.—Breadth: overall 27·0 (34·0) 40·0 microns; corpus 10·0 (13·0) 19·0 microns; saccus 11·0 (15·0) 19·0 microns. Length: corpus 16·0 (20·0) 27·0 microns; saccus 17·0 (21·0) 27·0 microns.

*Distribution*.—Widespread in Mesozoic sediments; Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Indusiisporites* Leschik, 1955

*Type species* (by original designation).—*Indusiisporites velatus* Leschik, 1955.

*Indusiisporites parvisaccatus* (de Jersey) de Jersey, 1963

Pl. 6, figs 7, 8

1959 *Pityosporites parvisaccatus* de Jersey, p. 363, pl. 3, fig. 10.

*Description*.—Pollen grains bisaccate. Corpus subquadrate to circular in equatorial outline, oval in lateral aspect. Cappa approximately 1·5 microns thick, densely microrugulate and granulate; microrugulae 1·0–4·0 microns long (mostly 1·0 micron), less than 0·5 micron wide. Cappula smooth, narrow (average width 10·0 microns), subquadrate; linear colpus (0·5 micron wide) rarely developed. Sacci clearly separate, usually smaller than corpus, elongate to broadly elliptical in polar view, semicircular in lateral view, attached subequatorially and distally; strongly developed infrareticulum of muri (approximately 0·5 micron wide) enclosing irregularly polygonal lumina 2·0–10·0 microns in maximum diameter.

*Dimensions*.—Breadth: overall 37·0 (54·0) 68·0 microns; corpus 35·0 (45·0) 63·0 microns; saccus 14·0 (22·0) 31·0 microns. Length: corpus 48·0 (58·0) 71·0 microns; saccus 46·0 (51·0) 65·0 microns. Depth (6 specimens): corpus 22·0 (32·0) 48·0 microns; saccus 28·0 (32·0) 40·0 microns.

*Remarks*.—Leschik (1955, p. 55) defined *Indusiisporites* as having an oval to rounded, granulate corpus with non-reticulate sacci. *Indusiisporites parvisaccatus* has reticulate sacci and a microrugulate cappa, and therefore the generic assignment may be open to question. However, it has the distally placed, unconstricted sacci of *Indusiisporites*.

de Jersey (1959, p. 363) originally described the species from the Rosewood Coalfield as having a smooth to faintly granulate cappa, and sacci with a fine indistinct reticulum. de Jersey & Paten (1964, p. 13) noted that structures suggestive of an incomplete coarse reticulum within the sacci of specimens of *I. parvisaccatus* might be the remains of tissue normally destroyed by the maceration technique employed. Well preserved specimens observed in the present study exhibit a strong saccus reticulum and a microrugulate cappa sculpture; on other grains these features are often not clear. Samples from the horizon of the holotype were macerated in Schulze solution for periods of up to three hours and the specimens of *I. parvisaccatus* observed were poorly preserved and the saccus reticulum and cappa ornament were either not preserved or were very indistinct. Thus it would appear that these features are strongly affected by local conditions of preservation. Similar differences of preservation have been observed in specimens of other saccate pollen, e.g. *Podosporites* sp., *Vitreisporites pallidus* (Reissinger) Nilsson, 1958.

*Comparison*.—The species is distinctive in the relative size and placement of the sacci, and in the strong saccus reticulum. *Pteruchipollenites microsaccus* Couper, 1958 (p. 151, pl. 26, fig. 13) shows



close resemblance to the present form in the arrangement of the sacci, but the saccus reticulum is much finer. Danzé-Corsin & Laveine (1963, p. 103, pl. 10, fig. 22) figured a specimen, *Pinuspollenites* sp., from the Infraliassic of France, which is similar to the present form. The various dimensions of this grain correspond with those of *I. parvisaccatus*, but the saccus reticulum of the French form is not described in detail.

*Distribution*.—Walloon Coal Measures, Queensland (de Jersey, 1959); Marburg Sandstone, Queensland (de Jersey, 1963); Precipice Sandstone to Blythesdale Group, Surat Basin (de Jersey & Paten, 1964; Paten, 1967); Razorback Beds, Queensland (Playford & Cornelius, 1967). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Subturma POLYSACCITES Cookson, 1947

Genus *Podosporites* Rao, 1943

*Type species* (by monotypy).—*Podosporites tripakshi* Rao, 1943.

*Podosporites* sp.

Pl. 6, figs 9, 10

*Description*.—Pollen grains trisaccate. Corpus circular to subcircular in equatorial outline. Cappa approximately 1.0 micron thick, sparsely to densely rugulate; rugulae low, rounded, often anastomosing, width 0.5 micron, irregularly disposed, sometimes forming an imperfect reticulum. Cappula smooth to scabrate, triradiate, consisting of a polar, roughly triangular area (sides approximately 7.0 microns long), with broad (2.5–7.0 microns wide), ray-like extensions to the equator. Sacci subequal, semi-circular in polar aspect, symmetrically placed, with distal and equatorial attachment; distal roots sharply defined, proximal roots not always clear, often apparently grading into cappa. Sculpture of sacci consisting of a more or less perfect reticulum, with low, rounded muri approximately 0.5 micron wide enclosing lumina 1.0–7.0 microns in maximum diameter.

*Dimensions*.—Equatorial corpus diameter 33.0 (48.0) 68.0 microns. Saccus: breadth 10.0 (19.0) 25.0 microns; length 22.0 (30.0) 43.0 microns.

*Remarks and comparison*.—This form is assigned to the genus *Podosporites* Rao, 1943 rather than *Microcachrydites* Cookson, 1947 on the grounds that there are no similar grains with more or fewer than three sacci, and that the generic definition *Podosporites* embraces a more clearly delineated morphological grouping.

These specimens are larger than the type species *P. tripakshi* Rao, 1943 and have a rugulate cappa. They differ from *P. ohikaensis* (Couper) Pocock, 1962 in their relatively larger sacci and well developed saccus reticulum. *Microcachrydites antarcticus*

Cookson, 1947 is smaller, with a faintly granulate proximal surface, and slightly reticulate sacci. The specimens appear to be identical to forms described as *Podosporites* sp. by de Jersey (1963) and de Jersey & Paten (1964), discrepancies in description being possibly due to preservation differences.

*Distribution*.—Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Turma PLICATES Naumova, 1939

Subturma MONOCOLPATES Iverson & Troels-Smith, 1950

Genus *Cycadopites* Wodehouse ex Wilson & Webster, 1946

*Type species* (by monotypy).—*Cycadopites follicularis* Wilson & Webster, 1946.

*Cycadopites nitidus* (Balme) de Jersey, 1964

*Distribution*.—Widely recorded from Australian sediments of Triassic to Cretaceous age. Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Turma POROSSES Naumova emend. Potonié, 1960

Subturma MONOPORINES Naumova, 1939

Genus *Classopollis* Pflug emend. de Jersey & Paten, 1964

1961 *Classopollis* Pflug emend. Pocock & Jansonius, p. 443.

1963 *Classopollenites* Danzé-Corsin & Laveine in Briche, Danzé-Corsin & Laveine, p. 107.

For remaining synonymy, see Pocock & Jansonius (1961, pp. 441–443).

*Type species* (by original designation).—*Classopollis classoides* Pflug emend. Pocock & Jansonius, 1961.

*Discussion*.—de Jersey & Paten's (1964) emendation of the genus is used as the authors agree with its purpose of including *Classopollis simplex* (Danzé-Corsin & Laveine) comb. nov. within the genus. The presence of a rimula (*sensu* Pflug, 1953) is considered to be of generic significance, but this is not made clear in either de Jersey & Paten's diagnosis or in that of Pocock & Jansonius (1961) on which it is based. However, further emendation of the genus would be unsatisfactory without a complete review of *Classopollis* and allied genera; this is not attempted in this paper.

Danzé-Corsin & Laveine's designation *Classopollenites* (in Briche et al. 1963, p. 107) is a junior synonym of *Classopollis*, because the former contravenes Article 73 of International Code of Botanical Nomenclature.

*Classopollis classoides* (Pflug) Pocock & Jansonius, 1961

Pl. 6, figs 13–14

*Description*.—Pollen grains monoporate, subspherical, with a conspicuous band of equatorial



thickening; amb subcircular. Exine two-layered. Intexine thin, smooth, often absent, even in well-preserved specimens; where present, forming a continuous layer under the exoexine. Intexine exposed in a subcircular distal polar pore 9.0–12.0 microns in diameter. Contact area in the form of an equilateral triangle with sides 11.0–13.0 microns in length, smooth near the margins, but bearing a central cluster of grana or hair-like processes, and rarely, a trilete mark with rays 2.0 microns long. Exoexine membranous, smooth; bearing inwardly projecting sculptural elements, the type and distribution of which define four distinct exoexinal zones: proximal zone surrounding the contact area, equatorial thickened zone, rimula, and a band around the distal pore. Proximal zone and distal band bear a finely, densely granulate internal sculpture. Rimula, 2.0 microns wide in lateral view, consists of the outer membranous layer of exine, separates distal annulus from equatorial zone. Equatorial zone, ca. 7.0 microns wide in lateral view; zone marked by six or seven discrete, parallel, more or less continuous bands formed by fusion at the surface of inwardly projecting bacula aligned in rows; bacula ca. 1.0–2.0 microns long, 0.5–1.0 micron in basal diameter.

*Dimensions.*—Equatorial diameter: 28.0 (30.0) 40.0 microns; polar diameter (six specimens): 25.0 (28.0) 36.0 microns.

*Remarks.*—The above description of *Classopollis classoides* (Pflug) Pocock & Jansonius, 1961 differs from that of Pocock & Jansonius (1961, p. 443) in the interpretation of exoexinal structure. The structural interpretation presented here was first presented by Harris (1957, p. 301); subsequently Chaloner (1962, p. 22) and Chaloner & Clarke (1962, p. 651) presented clear diagrams illustrating Harris's concept. Pettitt & Chaloner (1964, pp. 613–616) have confirmed this interpretation using electron microscopy.

*Distribution.*—Reported world-wide from Rhaetic to Tertiary strata. In Australia, the first appearance of *Classopollis classoides* is generally regarded as marking the base of the Jurassic; recorded from Jurassic and Cretaceous strata (de Jersey, 1963; de Jersey & Paten, 1964; Dettmann, 1963; Playford & Dettmann, 1965; Hill, Playford, & Woods, 1966). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

*Classopollis simplex* (Danzé-Corsin & Laveine),  
comb. nov.

Pl. 6, fig. 15

1963 *Classopollenites simplex* Danzé-Corsin & Laveine in Briche, Danzé-Corsin, & Laveine, p. 106, pl. 11, figs 7, 8.

1964 *Classopollis simplex* de Jersey & Paten, p. 12, pl. 7, figs 4–6.

*Description* (polar aspect only).—Pollen grains monoporate, amb subcircular. Exine thick, smooth, with a well-defined internal body. A narrow band of exoexinal thinning, the rimula, is immediately distal

of an equatorial, thickened girdle, 1.5–2.0 microns wide. Exine pierced distally by a polar pore 4.0–7.0 microns in diameter. Contact area in the form of an equilateral triangle with sides 5.0–8.0 microns long, sometimes with a trilete mark incised at the centre (rays ca 1.5 microns long). Equatorial diameter: 20.0 (27.0) 30.0 microns; diameter of internal body: 15.0 (20.0) 24.0 microns.

*Remarks.*—This species was first described by Danzé-Corsin & Laveine (in Briche *et al.*, 1963, p. 106, pl. 11, figs 7, 8) under the name *Classopollenites simplex* Danzé-Corsin & Laveine, 1963. According to Article 73 of International Code of Botanical Nomenclature, the generic name *Classopollenites* Danzé-Corsin & Laveine, 1963 is illegitimate. However, since the combination was validly published, the epithet *simplex* is still valid (Article 68); and de Jersey & Paten (1964, p. 12 pl. 7, figs 4–6) contravened Article 67, when, coincidentally, they used the same trivial name in the combination *Classopollis simplex* de Jersey & Paten, 1964 for grains identical with the French form. Hence, the correct name for the species is *Classopollis simplex* (Danzé-Corsin & Laveine) comb. nov. (see Article 11).

There was a notable absence of lateral compressions of *Classopollis simplex* in the material studied, although these were common in the case of *C. classoides*. The anomaly is thought to be a result of differences in equatorial girdle structure between the two species. The descriptions of both Danzé-Corsin & Laveine (in Briche *et al.*, 1963, p. 106) and de Jersey & Paten (1964, p. 12) suggest that the equatorial girdle of *C. simplex* consists of a compact band 5.0 microns wide in lateral view (de Jersey & Paten's measurement) and 1.5–2.0 microns thick; the equatorial girdle of *C. classoides*, on the other hand, consists of discrete rows of bacula, fused only at the surface; and separated by the membranous outer layer of the exoexine. The difference in mechanical strength between girdle and rimula would thus be much more pronounced in *C. simplex*, permitting much easier compression from the poles than from a lateral direction.

*Distribution.*—Widespread in Jurassic and France (e.g. Danzé-Corsin & Laveine in Briche *et al.*, 1963) and from Lower Jurassic sediments of the Surat Basin, Queensland (de Jersey & Paten, 1964; Hill, Playford, & Woods, 1966). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Perinopollenites* Couper, 1958

*Type species* (by original designation).—*Perinopollenites elatoides* Couper, 1958.

*Perinopollenites elatoides* Couper, 1958

Pl. 6, figs 11, 12

*Distribution.*—Widespread in Jurassic and Lower Cretaceous sediments of Europe and Canada;



Precipice Sandstone to Walloon Formation (de Jersey & Paten, 1964); Marburg Sandstone (de Jersey, 1963). Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (this paper).

Turma ALETES Ibrahim, 1933  
Subturma AZONALETES Lubér *emend.* Potonié & Kremp, 1954

Genus *Inaperturopollenites* Thomson & Pflug, 1953

Type species (by original designation).—*Inaperturopollenites dubius* (Potonié) Thomson & Pflug, 1953.

*Inaperturopollenites turbatus* Balme, 1957

Pl. 5, figs 9, 10

*Remarks.*—The specimens appear to be identical with those described by Balme (1957), but their structure is not clear. Forms described as *Laricoidites triquetrus* Lantz, 1958 (p. 926, pl. 5, figs 51–54) appear to be identical with the present specimens.

*Distribution.*—Liassic to Oxfordian of Western Australia (Balme, 1957); Toarcian to Lower Cretaceous of Europe (Schulz & Mai, 1966; Döring, 1966a, b; Schulz, 1967); upper Evergreen Formation to Blythesdale Group, Surat Basin (de Jersey & Paten, 1964; Paten, 1967); Marburg Sandstone (de Jersey, 1963). Upper Evergreen Formation, lower Hutton Sandstone (this paper).

Genus *Araucariacites* Cookson ex Couper, 1953

Type species (by subsequent designation of Couper, 1953, p. 39).—*Araucariacites australis* Cookson, 1947.

*Araucariacites fissus* sp. nov.

Pl. 5, figs 11–17

1966 Aff. *Schizosporis* sp. in Hill, Playford, & Woods, p. j 26, pl. J 12, figs 10, 11.

*Diagnosis.*—Spores originally alete, with a tendency to split into two more or less equal parts. Exine one layered, 1.0–2.0 microns thick, finely granulate. Undivided forms with oval to rounded outline. In divided forms, where separation of the two parts is complete or nearly so, the margins of each part are usually folded inwards; there may be from two to several folds, usually three, giving a triangular to subcircular outline. The line of separation is irregular, but may be straightened by narrow marginal folds. Diameter : 34.0 (57.0) 95.0 microns.

*Holotype.*—Slide S. 1225 : 42.4, 83.8.

*Description.*—Spore split open. Division approximately  $\frac{3}{4}$  complete. Two folds of approximately equal dimensions formed on each part, giving a convexly subtriangular outline. Edges of split exine irregular, in one case straightened by a narrow marginal fold. Exine finely granulate, 1.5 microns thick. Diameter 76.0 microns.

Type locality.—G.S.Q. D.R.D. No. 6 at 310 ft. 2 in. Evergreen Formation, Surat Basin, Queensland. Queensland.

*Remarks.*—The specimens have been included in one species as they form a gradational series; this range of morphology may be related to a mechanism of germination. Whether there is any interrelation between folding and splitting, and whether the splitting has a characteristic orientation in relation to the poles are not known. Several specimens show division  $\frac{3}{4}$ – $\frac{4}{4}$  complete with two major folds formed, the undivided part being straight or arcuate; final division may give a fold equal to or shorter than the other two. The folding is such that the two parts of one spore are not always mirror images. Final separation of two parts may occur at the junction of two folds or at any point along a fold. Although three folds are usually present on each part, there may be more or less; a few of the divided forms are not folded at the margins.

No indication of an original line of weakness or tenuitas has been observed, and the splitting does not occur along clearly demarcated sutures or colpi.

*Comparison.*—As the nature of the division in the spores recorded here is not definitely known, and as the alete forms are indistinguishable from *Araucariacites australis* Cookson, 1947, they are referred to the genus *Araucariacites* Cookson ex Couper, 1953. However the distinctive morphological series described here was not mentioned in the original description of *A. australis*, nor in later records of it.

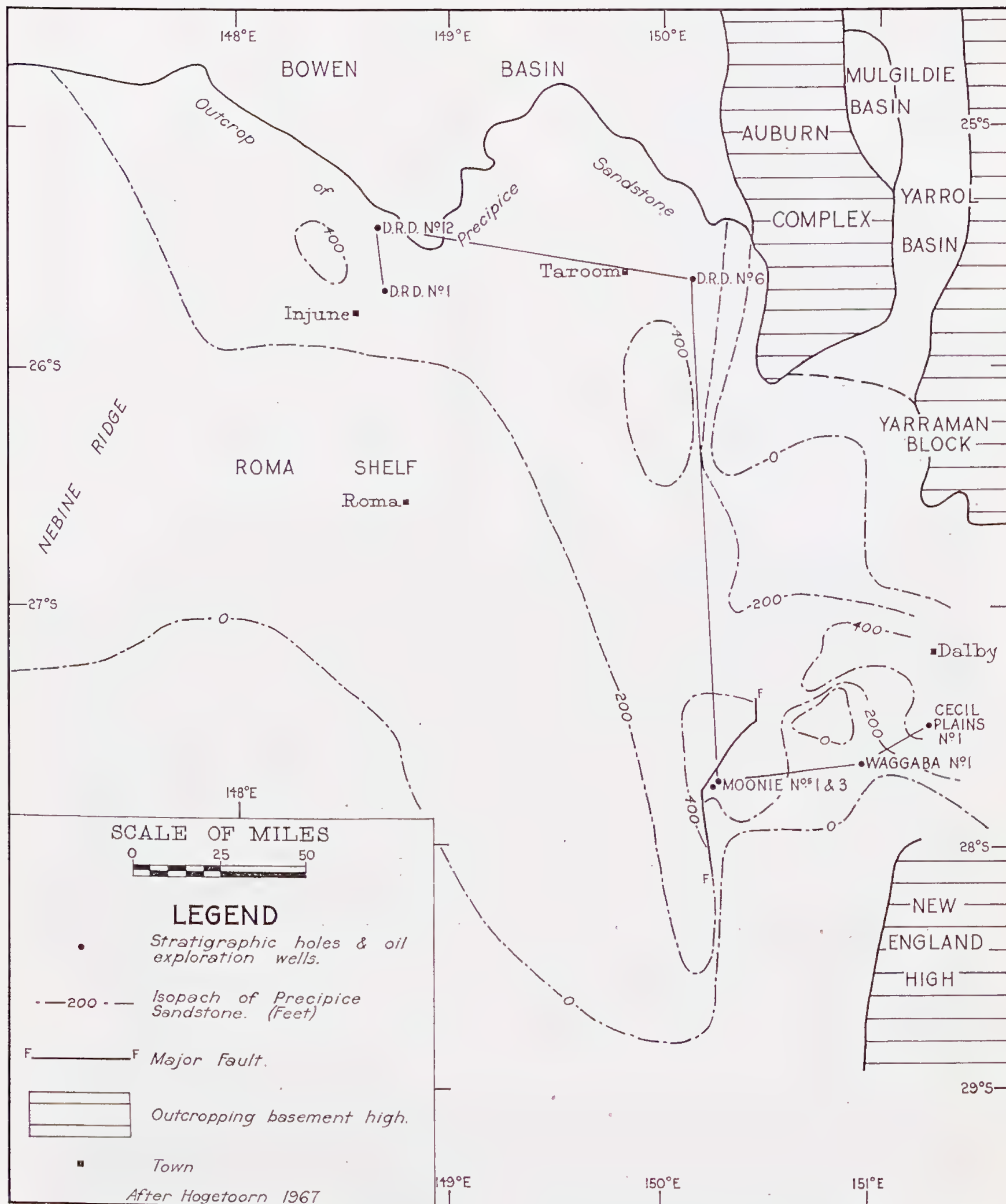
Somewhat similar modes of splitting and folding have been recorded: some of the central bodies of *P. elatoides* Couper, 1958 split identically; *Taxodiaceapollenites* Kremp, 1949 is described as tending to burst open along a radial line, giving a beak-like aperture. The specimen described as *Inaperturopollenites hiatus* (Potonié) Pflug & Thomson, 1953 by Groot, Penny, & Groot (1961, p. 130, pl. 24, fig. 16) is very similar to *Araucariacites fissus* sp. nov., but has a smooth exine. *Inaperturopollenites* sp., Type A. (Manum, 1962, p. 40, pl. 11, figs 10–16) may split open, but the margins are unfolded.

## DISCUSSION OF THE MICROFLORAS

### Introduction

In Australia the first palynological paper of significance to Mesozoic stratigraphy was by Balme (1957), who worked on a Western Australian sequence in which marine intercalations had been correlated with European stages, enabling him to relate his microfloras to the standard subdivisions of the Jurassic system. The lower Jurassic sediments in eastern Australia are not accurately dated by marine fossils, but to some extent they can be related to those studied by Balme. They have been the subject





TEXT-FIG. 2. Sketch map of the Surat Basin showing the locations of wells used for text-fig. 3



of publications by de Jersey (1959, 1963), de Jersey & Paten (1963 a, b, 1964), Evans (1963, 1964, 1966), Playford & Dettmann (1965), and Paten (1967), and of unpublished reports of the Bureau of Mineral Resources and the Geological Survey of Queensland. The palynological subdivisions of the lower Jurassic (set forth in part by Evans, 1966) are widely accepted, and this discussion seeks only to formalise them according to the fourth edition of the Australian Code of Stratigraphic Nomenclature. Published data have been utilized, and some unpublished material is quoted, with the authors' permission.

### Microfloral Distribution

The following are the main features of the microfloral distribution (illustrated by the present data in figs 3, 4, and 5).

- (1) The dominance of assemblages in the Precipice Sandstone and lower Evergreen Formation by *Classopollis classoides*.
- (2) The first appearance of *Tsugaepollenites* spp. in the Evergreen Formation.
- (3) The first appearance of *Nevesisporites vallatus* within the *C. classoides* dominated interval.

On this evidence the microfloral succession is divided into two parts: the *Classopollis classoides* Zone and the succeeding *Tsugaepollenites segmentatus*–*T. dampieri* "zone". The *C. classoides* Zone and two Subzones within it are proposed formally according to the fourth edition of the Australian Code of Stratigraphic Nomenclature. A *T. segmentatus*–*T. dampieri* "zone" is outlined, but not formally proposed in this paper, since the upper limit of the "zone" was not encountered in the interval studied.

### The CLASSOPOLLIS CLASSOIDES Zone, (Surat Basin, Queensland)

The zone is defined by the presence of *C. classoides* and the absence of *Tsugaepollenites* spp. The lower limit of the zone is the lowest horizon at which *C. classoides* first appears; the upper limit is defined as the level of the first appearance of *Tsugaepollenites* spp.

*Polycingulatisporites mooniensis* is found persistently within the zone, but its last occurrence does not always coincide with the first appearance of *Tsugaepollenites* spp. *Nevesisporites vallatus* occurs first within the zone and is the basis for dividing it into two subzones.

### The CLASSOPOLLIS CLASSOIDES Subzone of the C. CLASSOIDES Zone, (Surat Basin, Queensland)

The base of the subzone is defined by the first appearance of *C. classoides* and its upper limit by the first appearance of *N. vallatus*. It constitutes the lower part of the *C. classoides* Zone.

### The NEVESISPORITES VALLATUS Subzone of the C. CLASSOIDES Zone, (Surat Basin, Queensland)

The subzone is defined at its base by the first appearance of *N. vallatus* and extends to the top of the *C. classoides* Zone (that is, to the first appearance of *Tsugaepollenites* spp.). *N. vallatus* occurs quite consistently with these limits but only sporadically above the subzone.

The zone and subzones are based on core samples from G.S.Q. D.R.D. Nos. 1, 6 and 12. The base of *C. classoides* Zone in the northern Surat Basin is at an unconformity; the top is in the Evergreen Formation, at or near the base of the Boxvale Sandstone or Westgrove Ironstone Member. The base of the *N. vallatus* Subzone is here in the Precipice Sandstone.

### The *Tsugaepollenites segmentatus*–*T. dampieri* "zone"

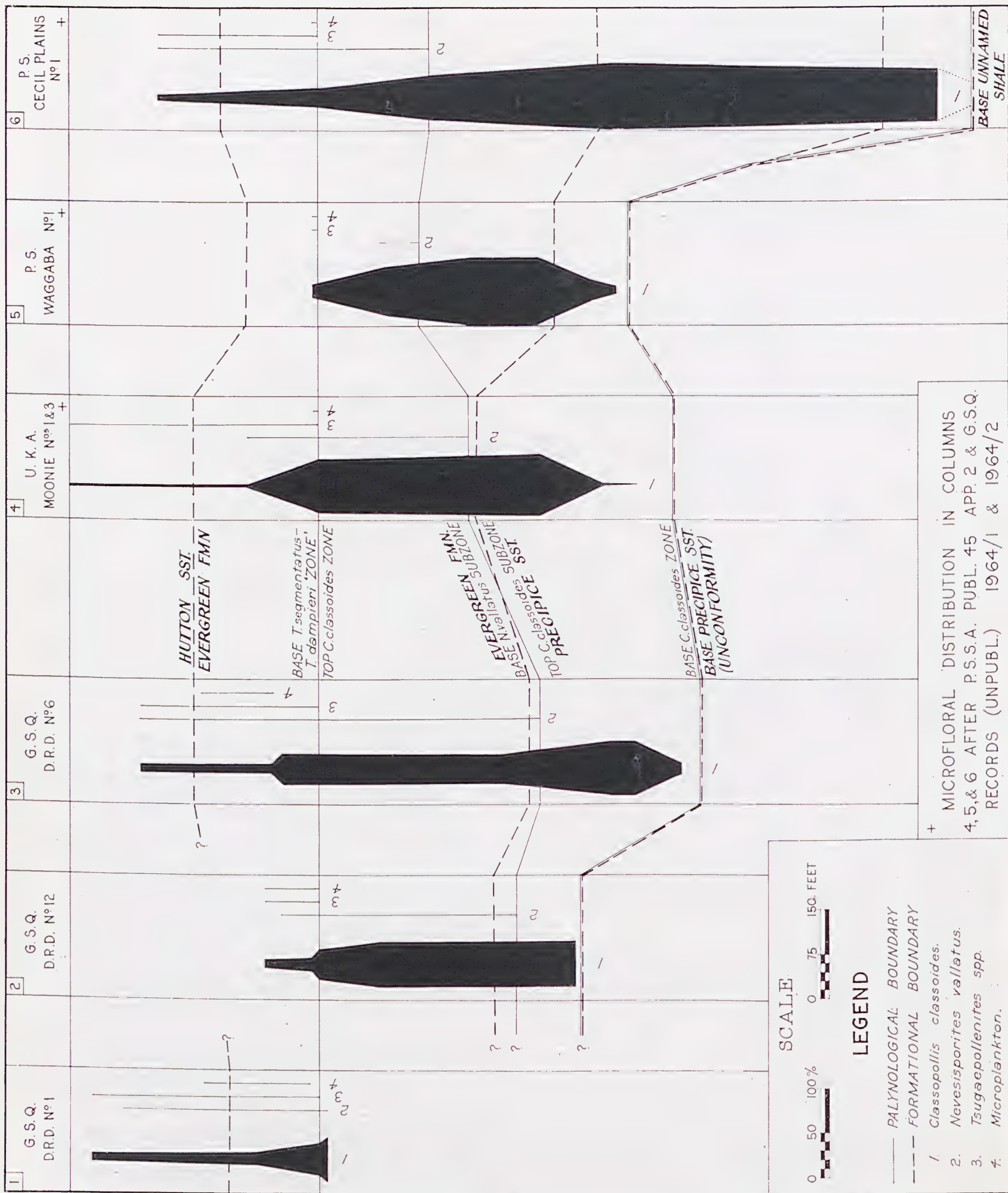
This is not proposed formally as a zone because no satisfactory upper limit is available from the present study. It is possible that *Cingulatisporites saevus*, *Murospora florida*, or *Contignisporites cooksonii* may prove useful in this respect; *C. saevus* occurs in the highest sample from D.R.D. No. 1. The appearance of *Tsugaepollenites segmentatus* and *T. dampieri* delimits the base of the assemblage, and at or just above this horizon *Inaperturopollenites turbatus* first appears. Microplankton occur associated with the Boxvale Sandstone and Westgrove Ironstone Member, often in considerable numbers. The base of the "zone" occurs consistently in the Evergreen Formation in the Surat Basin.

Forms commonly found in both the *C. classoides* Zone and the *T. segmentatus*–*T. dampieri* "zone" include *Araucariacites fissus*, *Perinopollenites elatoides*, *Alisporites* spp., *Lycopodiumsporites* spp., *Osmundacidites* spp., *Vitreisporites pallidus*, *Stereisporites* spp., *Cyathidites* spp. and *Baculatisporites* spp. Forms found in both assemblages, but more commonly in the *C. classoides* Zone include *Classopollis classoides*, *Anapiculatisporites dawsonensis*, *Antulsporites vari-granulatus*, *Camarozonosporites rudis*, *Cadargasporites baculatus* and *Polycingulatisporites mooniensis*. *Foraminisporis tribulosus* was recorded only in the basal sample of D.R.D. No. 6 at the base of the *C. classoides* Zone and may prove to be of stratigraphical use. Forms found in both assemblages, but more commonly in the *T. segmentatus*–*T. dampieri* "zone" include *Ischvosporites marburgensis*, *Dictyophyllidites mortoni*, *Trilobosporites antiquus* and *Staplinisporites caminus*.

The *C. classoides* Zone corresponds to the informal unit J 1, and the base of the *T. segmentatus*–*T. dampieri* "zone" to the base of the informal unit J 2, of Evans (1966). Paten (1967) regarded *N. vallatus* as a "significant time marker".

In all three holes studied, microplankton appear suddenly, accompanied by a significant decrease in the percentage of *C. classoides*, which above this level comprises less than 35 per cent. of the assemblages.





TEXT-FIG. 3 Microfloral sequences in the Surat Basin illustrating the extent of the zone and subzones proposed in this paper.



The horizon at which microplankton first appear varies from 0 ft.–60 ft. above the base of the *T. segmentatus*–*T. dampieri* “zone”. The appearance of *Tsugaepollenites* spp. is preferred to the microplankton as a zonal marker as their distribution is more likely to be independent of facies. A comparison of the results of this study with those of three wells studied previously at the Geological Survey of Queensland shows that the zone and subzones proposed above can be traced in the south of the basin. The wells are Union–Kern–A.O.G. Moonie Nos. 1 & 3, Phillips–Sunray Waggaba No. 1, and Cecil Plains No. 1. Their positions and a correlation between the six wells are illustrated in text-figs 2 and 3. In text-fig. 3 the first appearance of *Tsugaepollenites* spp. is taken as the datum line. The base of the section and of the *C. classoides* Zone in all six wells is at unconformity. In P.–S. Cecil Plains No. 1 well, an unnamed shale unit conformably underlies the Precipice Sandstone and is unconformable upon the underlying strata.

The diachronism suggested by the relationship between the base of the *N. vallatus* Subzone and the Precipice Sandstone–Evergreen Formation boundary was pointed out by R. J. Paten in an address to the Geological Society of Australia (Brisbane, 1966, unpubl.). *N. vallatus* is also present in the lowest horizons of the Precipice Sandstone sampled on the Roma Shelf (Paten, pers. comm.). This suggests that the Precipice Sandstone in the north and west of the basin is younger than in the south-east, and in part coeval with the lower part of the Evergreen Formation there.

The interval containing microplankton occurs at or just above the incoming of *Tsugaepollenites* spp., with acmes at the base of the Boxvale Sandstone (which occurs only in the west of the basin), and in the Westgrove Ironstone Member. Evans (1966) traced two zones of microplankton across the basin. Within this interval the lithology of part of the Westgrove Ironstone Member (chamositic oolite) is suggestive of marine origin. Acritarchs have been found associated with marine, brackish, and freshwater deposits (e.g. Staplin, 1961; Hughes & Moody-Stuart, 1967; Varma, 1964). A few arenaceous foraminifera have been found within the acritarch interval at Moonie (Evans, 1966), but there are no reports of other occurrences. Thus, although a widespread change of environment is indicated at this interval, it is uncertain whether or not there was a true marine incursion.

#### Correlation with other Queensland Microfloras

Evans (1966) reported occurrences of his unit J 1 (*C. classoides* Zone) from the north-eastern Eromanga and the Yarrol Basins. On the basis of isopachs of unit J 1 he suggested that sedimentation continued into the Moreton Basin to the east. He stated also that there appeared to be no eastward barrier to unit J 2. Correlates of the *C. classoides* zone in the Moreton Basin are not well documented.

The Marburg Sandstone (de Jersey, 1963) and sediments in the Heifer Creek region (Robinson, 1963, unpubl.) contain microfloras in part comparable with those of the *T. segmentatus*–*T. dampieri* “zone”. Samples studied at the Geological Survey of Queensland show that both units are present in the Moreton and Yarrol Basins. The Nambour Basin has yielded a microfloral succession which includes equivalents of the sequence in the Surat Basin (de Jersey & Paten, 1963b; Paten, 1966, unpubl.). Assemblages from Mount Morgan, near Rockhampton (Playford & Cornelius, 1967), may be correlated with *C. classoides* Zone.

#### THE AGE OF THE MICROFLORAS

Balme (1957) gave a pre-Bajocian, probably upper Liassic age for Western Australian assemblages containing abundant *Classopollis*, *Tsugaepollenites segmentatus* and *Inaperturopollenites turbatus*; the upper Evergreen Formation assemblages may be correlated with these. Playford and Dettmann (1965) considered the Leigh Creek Coal Measures to be of Rhaeto-Liassic age. The younger microflora that they recorded is similar to the lower assemblages of the Surat Basin; it is characterized by the first appearance, and sudden increase in abundance, of *C. classoides*. Reyre (1966) recorded a microfloral sequence from the ?Lower to Middle Jurassic of Tunisia which has gross similarities to the Surat Basin sequence, in the increasing abundance of *Classopollis* and the first appearance of *Tsugaepollenites* (al. *Applanopsis*) spp.

*T. segmentatus*, *T. dampieri*, *T. trilobatus*, and *I. turbatus* have been recorded frequently from Liassic and younger beds (e.g. Balme, 1957; Lantz, 1958; Pocock, 1962; Dettmann, 1963). Schulz and Mai (1966) and Schulz (1967) record the first appearance of *T. dampieri* and *I. turbatus* in the Toarcian; this again suggests an Upper Liassic age for the upper Evergreen Formation. *C. classoides* has been widely recorded, but not definitely from sediments older than Rhaetic. Chaloner (1962) reported that in north-western Europe *Classopollis* appeared to dominate the microfloral assemblages of the Rhaeto-Liassic and Purbeckian. This is added evidence for a Rhaetic to Liassic age for the Precipice Sandstone and lower Evergreen Formation where *C. classoides* dominates the assemblages, although not to such a degree as in Europe. However the abundance of *Classopollis* may have been strongly affected by local environment (cf. Pocock and Jansonius, 1961; Venkatachala and Goczan, 1964). In Europe *Camarozonosporites rudis* has been observed in Carnian to Rhaetic, and rarely from Liassic sediments (Klaus, pers. comm.). It may however range well into the Jurassic in Queensland (one specimen observed in Walloon Coal Measures equivalents; R. E. Gould, pers. comm.). Other species recorded in this study which have been reported from both Triassic and Jurassic sediments include *Baculatisporites comaumensis*, *Cycadopites nitidus*, *Annulispora folliculosa*, *Stereisporites perforatus* and



*Vitreisporites pallidus*. Those not known definitely from strata older than Jurassic include *Lycopodiumsporites austroclavatidites*, *Gleicheniidites senonicus* and *Staplinisporites caminus*. No species of *Contignisporites* are known from the Triassic, and *Trilobosporites* has not been previously recorded below precisely dated Upper Jurassic-Lower Cretaceous beds.

Compared with other described microfloras, those recorded from the Precipice Sandstone, Evergreen Formation and lower Hutton Sandstone show more resemblance to Jurassic than to Triassic assemblages. The upper Evergreen Formation appears to be of Upper Liassic age, but the lower part of the sequence is less precisely dated, and although probably Liassic, may possibly be as old as Rhaetic.

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## PLATE 1

FIG. 1. *Stereisporites perforatus* Leschik. Median focus (x 1,000). R24/2: 40·1, 94·9.

FIG. 2. *Cyathidites minor* Couper. Median focus (x 750). S. 1239: 28·8, 118·4.

FIG. 3. *Cyathidites australis* Couper. Median focus (x 750). S. 1212: 44·3, 96·9.

FIG. 4. *Dictyophyllidites mortoni* (de Jersey) Playford & Dettmann. Proximal focus (x 1,000). S. 1277: 36·3, 93·0.

FIG. 5. *Granulatisporites* sp. Median focus (x 1,000). S. 977: 42·3, 98·0.

FIGS 6–8. *Apiculatisporis taroomensis* sp. nov. Holotype (x 1,000). S. 1254: 37·0, 100·1.

Fig. 6. Proximal focus showing fine proximal ornament.

Fig. 7. Median focus.

Fig. 8. Distal focus.

FIGS 9–11. *Anapiculatisporites dawsonensis* sp. nov.

Figs 9, 10. Holotype. S. 1223: 28·2, 96·0. Fig. 9. Proximal focus (x 750). Fig. 10. Distal focus (x 1,000).

Fig. 11. Median focus (x 750). S. 1223: 47·7, 108·8.

FIGS 12–14. *Anapiculatisporites pristidentatus* sp. nov. Holotype (x 1,000). S. 1253: 44·0, 115·4.

Fig. 12. Proximal focus showing folds bordering laesurae.

Fig. 13. Equatorial focus showing walls and ornament in optical section.

Fig. 14. Distal focus.



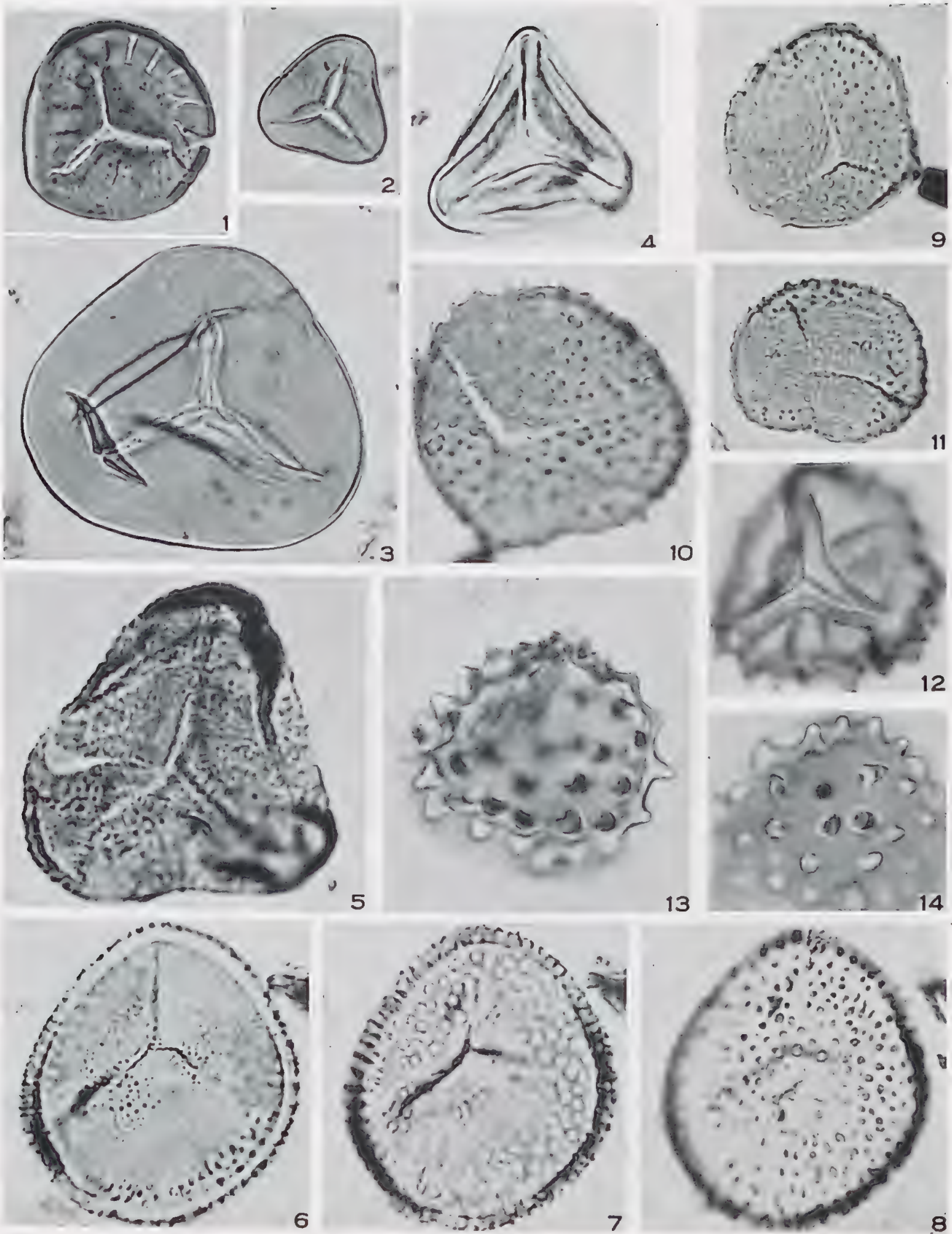


PLATE 1



## PLATE 2

FIGS 1-3. *Neoraistrickia elongata* sp. nov. Holotype. R22/3: 32·2, 104·6.

Fig. 1. Proximal focus (x 750).

Fig. 2. Median focus (x 1,000).

Fig. 3. Distal focus (x 1,000).

FIGS 4-6. *Cadargasporites baculatus* (de Jersey & Paten) *emend.*

Fig. 4. Proximal focus showing membranous lips of the exoexine developed over the simple sutures of the intexine (x 1,000). R20/3: 47·4, 112·2.

Fig. 5. Lateral view showing details of sculpture and the membranous nature of the exoexine of the contact area (x 750). S. 1233: 32·8, 97·9.

Fig. 6. Median focus showing intexine folded away from exoexine (x 750). R26/3: 37·9, 100·9.

FIGS 7-9. *Cadargasporites granulatus* (de Jersey & Paten) *emend.*

Fig. 7. Off-polar orientation showing two-layered exine, and tri-lobed contact area (x 1,000). R28/3: 36·5, 115·7.

Fig. 8. Proximal focus (x 1,000). S. 1253: 29·5, 92·3.

Fig. 9. Distal focus showing well developed reticulum surmounted by grana (x 1,000). S. 1254: 35·1, 103·0.

FIGS 10-13. *Cadargasporites verrucosus* sp. nov.

Figs 10, 11. Holotype (x 1,000). R27/3: 42·1, 86·2. Fig. 10. Proximal focus. Fig. 11. Median focus.

Figs 12, 13. R27/3: 32·4, 89·8. Fig. 12. Proximal focus (x 1,000). Fig. 13. Median focus showing intexine folded independently of exoexine (x 1,000).



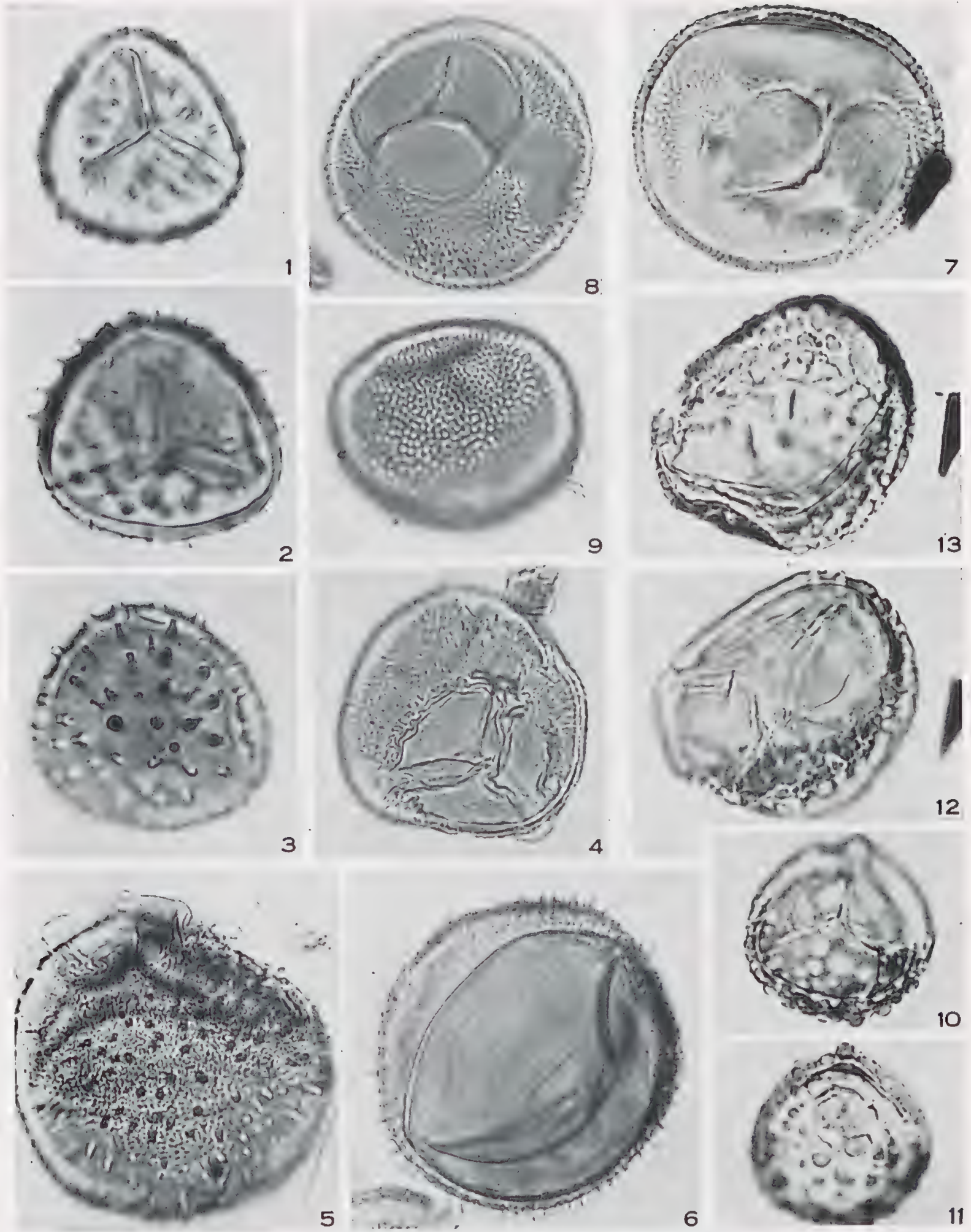


PLATE 2



### PLATE 3

FIGS 1, 2. *Cadargasporites verrucosus* sp. nov.

Fig. 1. Distal focus (x 1,000). S. 1223: 44·9, 112·0.

Fig. 2. Tetrad (x 500). S. 1229: 40·9, 100·9.

FIGS 3–5. *Cadargasporites reticulatus* de Jersey & Paten.

Fig. 3. Proximal focus, showing membranous exoexine of contact area, and sutures of intexine opened to form a triangular area (x 1,000). R22/5: 45·9, 87·8.

Figs 4, 5. R23/1: 33·8, 104·5. Fig. 4. Median focus showing two-layered exine (x 1,000). Fig. 5. Distal focus showing reticulum and "pattern" on intervening exoexine (x 1,000).

FIG. 6. *Foveosporites* sp. Distal focus (x 1,000). S. 977: 45·9, 93·1.

FIGS 7, 8. *Lycopodiumsporites austroclavatidites* (Cookson) Potonié.

Fig. 7. Proximal focus (x 750). R22/2: 47·4, 108·7.

Fig. 8. Distal focus (x 750). S. 1223: 27·1, 105·2.

FIGS 9, 10. *Lycopodiumsporites rosewoodensis* (de Jersey) de Jersey.

Fig. 9. Distal focus (x 750). R27/3: 31·9, 116·7.

Fig. 10. Distal focus of a specimen with roundly subtriangular amb. R24/5: 43·1, 102·8.

FIG. 11. *Lycopodiumsporites semimuris* (Danzé-Corsin & Laveine) comb. nov. Distal focus (x 750). R23/1: 36·6, 109·8.

FIG. 12. *Duplexisporites gyratus* Playford & Dettman. Distal focus (x 750). R22/2: 27·0, 102·2.

FIG. 13. *Staplinisporites* sp. cf. *S. caminus* (Balme) Pocock. Proximal focus (x 750). S. 1200: 41·9, 92·8.

FIG. 14. *Staplinisporites caminus* (Balme) Pocock. Median focus (x 500). S. 1214: 30·1, 97·5.

FIG. 15. *Trilobosporites antiquus* sp. nov. Holotype (x 750). Median focus. S. 1243: 38·9, 116·0.

FIG. 16. *Ischyosporites marburgensis* de Jersey. Distal focus (x 750). S. 1223: 38·1, 86·9.



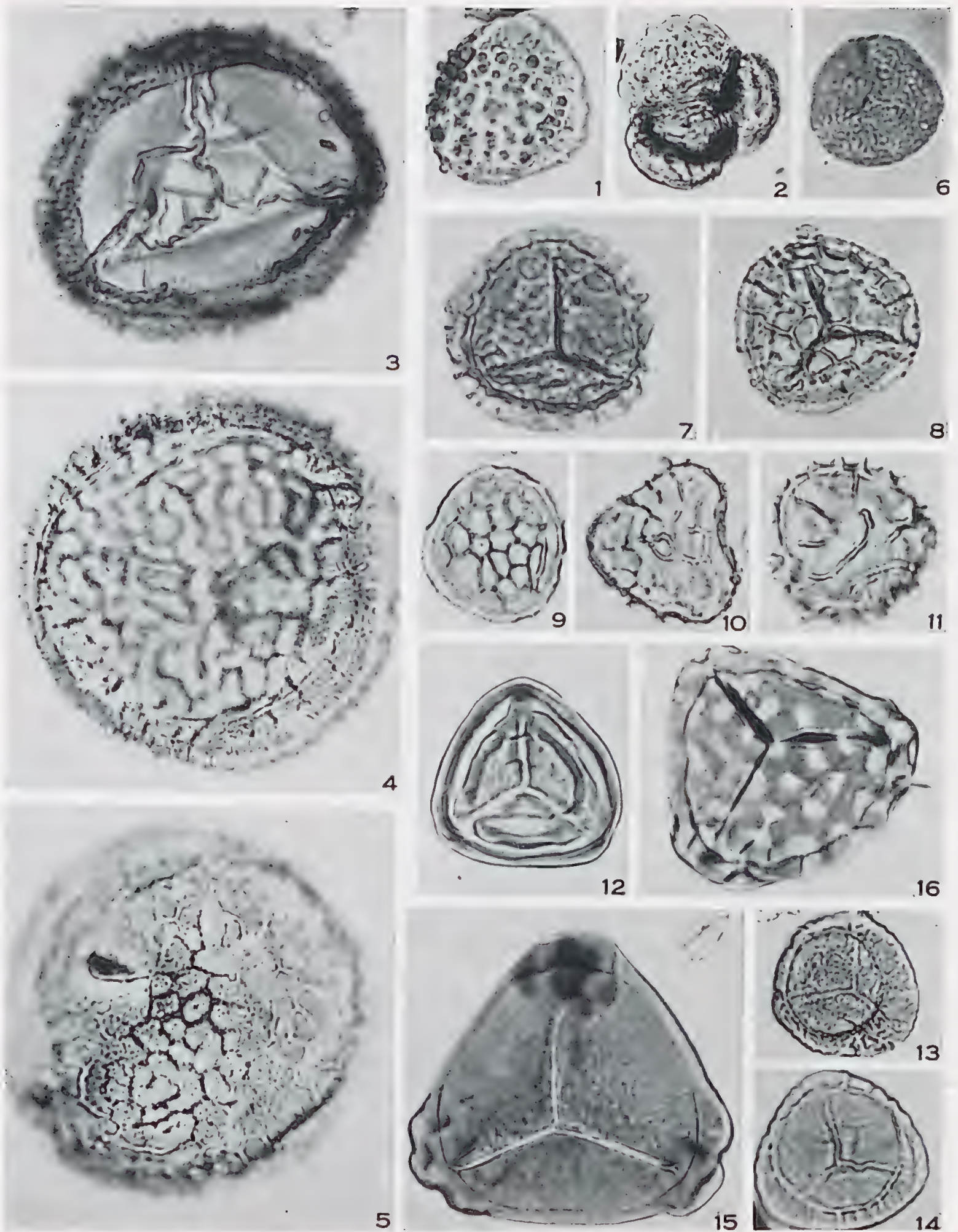


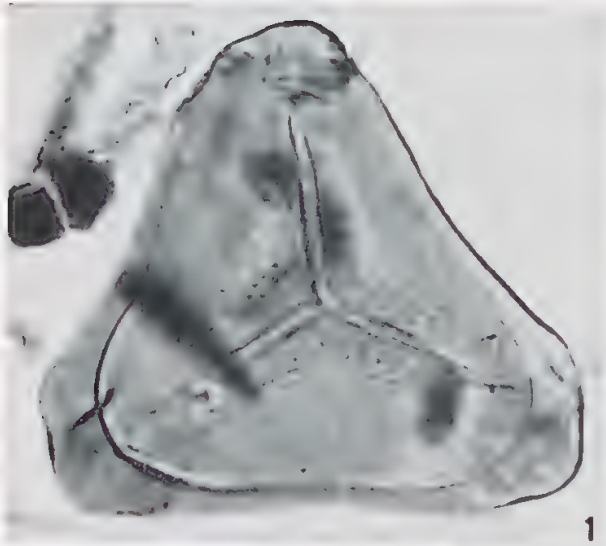
PLATE 3



#### PLATE 4

- FIG. 1. *Trilobosporites antiquus* sp. nov. Proximal focus (x 750).  
S. 1223: 27·1, 99·8.
- FIG. 2. *Gleicheniidites senonicus* Ross. Median focus (x 1,000).  
S. 1188: 30·7, 103·1.
- FIGS 3–5. *Camarozonosporites rudis* (Leschik) Klaus.
- Fig. 3. Proximal focus (x 1,000). R27/3: 42·3, 99·5.
- Fig. 4. Distal focus showing the basal outlines of the rugulae  
(x 1,000). R24/2: 47·9, 78·6.
- Fig. 5. Distal focus (x 1,000). S. 1252: 35·6, 100·6.
- FIGS 6, 7. *Cinguliriletes* sp. cf. *C. clavus* (Baume) Dettmann.
- Fig. 6. Median focus (x 750). R23/2: 47·1, 81·1.
- Fig. 7. Proximal focus (x 1,000). R24/5: 41·7, 103·0.
- FIGS 8, 9. *Antulsporites varigranulatus* (Danzé-Corsin & Laveine)  
comb. nov. S. 1253: 41·3, 117·3.
- Fig. 8. Proximal focus (x 1,000).
- Fig. 9. Distal focus (x 1,000).
- FIG. 10. *Foraminisporis tribulosus* Playford & Dettmann. Proximal  
focus (x 500). S. 1271: 43·2, 104·0.
- FIG. 11. *Nevesisporites vallatus* de Jersey & Paten. Proximal focus  
(x 1,000). S. 1234: 35·0, 111·2.
- FIGS 12, 13. *Foraminisporis caelatus* sp. nov. Holotype (x 1,000).  
S. 1024: 37·4, 105·4.
- Fig. 12. Distal focus.
- Fig. 13. Proximal focus.
- FIG. 14. *Polycingulatisporites mooniensis* de Jersey & Paten. Distal  
focus (x 750). R/24/5: 38·2, 105·0.





1



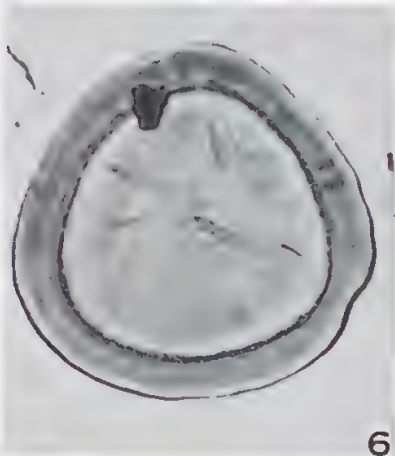
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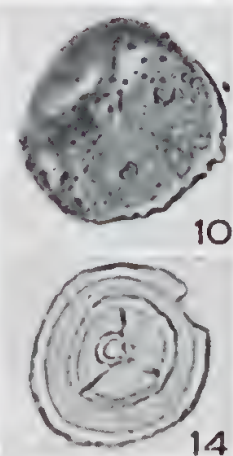
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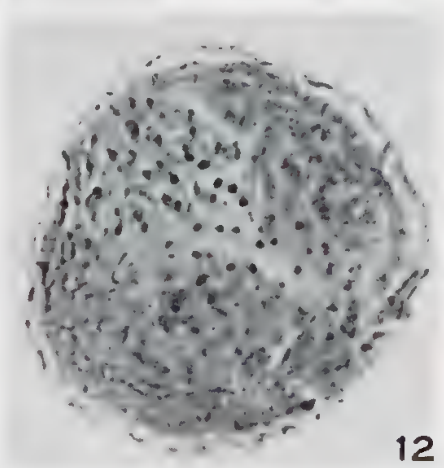
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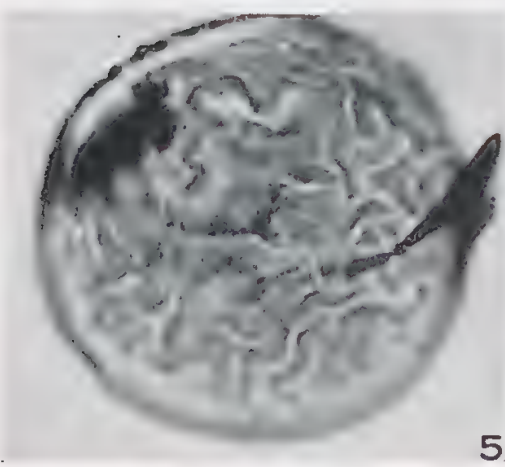
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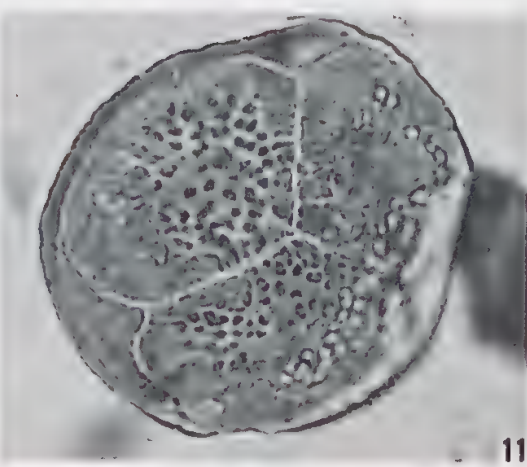
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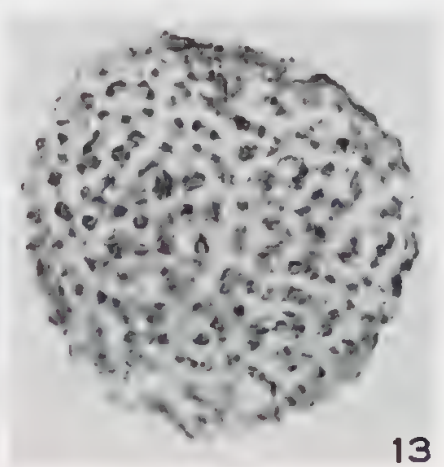
12



5



11



13

PLATE 4



## PLATE 5

- FIG. 1. *Polycingulatisporites mooniensis* de Jersey & Paten.  
Proximal focus showing unusually strongly thickened lips  
(x 1,000). R25/3: 31.5, 88.2.
- FIG. 2. *Polycingulatisporites crenulatus* Playford & Dettmann.  
Distal focus (x 750). R24/3: 48.1, 84.7.
- FIGS 3, 4. *Contignisporites* sp.
- Fig. 3. Distal focus (x 500). S. 913: 30.9, 99.2.
- Fig. 4. Lateral orientation showing cingulum and distal muri  
(x 750). S. 1282: 38.6, 97.8.
- FIGS 5-8. *Tsugaepollenites* spp.
- Fig. 5. *Tsugaepollenites* sp. cf. *T. dampieri* (Balme) Dettmann.  
Median focus (x 750). S. 1212: 35.1, 117.1.
- Fig. 6. *Tsugaepollenites dampieri* (Balme) Dettmann. Median  
focus (x 500). S. 1209: 45.8, 106.5.
- Fig. 7. *Tsugaepollenites trilobatus* (Balme) Dettmann. Median  
focus (x 750). S. 1244: 30.0, 86.6.
- Fig. 8. *Tsugaepollenites* sp. cf. *T. segmentatus* (Balme)  
Dettman. Distal focus (x 1,000). S. 1202: 36.8, 115.6.
- FIGS 9, 10. *Inaperturopollenites turbatus* Balme.
- Fig. 9. Median focus (x 750). S. 1215: 30.0, 115.1.
- Fig. 10. Median focus (x 500). S. 1205: 36.7, 95.5.
- FIGS 11-17. *Araucariacites fissus* sp. nov.
- Fig. 11. Median focus; no division apparent (x 500). S. 1186:  
44.6, 92.7.
- Fig. 12. Median focus; no sign of division developing; exine  
between the folds is unbroken (x 500). R24/4: 32.4,  
112.6.
- Fig. 13. Median focus; division commenced near amb on the  
right of the figure (x 500). S. 1231: 28.9, 105.9.
- Fig. 14. Holotype. Median focus; division two thirds complete,  
two major folds on each part (x 500). S. 1225: 42.2,  
83.7.
- Fig. 15. Median focus; final stage of division, three major  
folds formed on each part (x 500). S. 1230: 45.1, 116.9.
- Fig. 16. Median focus; final stage of division, folding at the  
margins irregular (x 500). S. 1132: 30.5, 94.4.
- Fig. 17. Median focus; isolated portion of completely divided  
specimen (x 500). S. 1064: 43.0, 98.6.
- FIG. 18. *Alisporites* sp. cf. *A. grandis* (Cookson) Dettmann.  
Median focus (x 500). S. 1224: 32.8, 90.0.



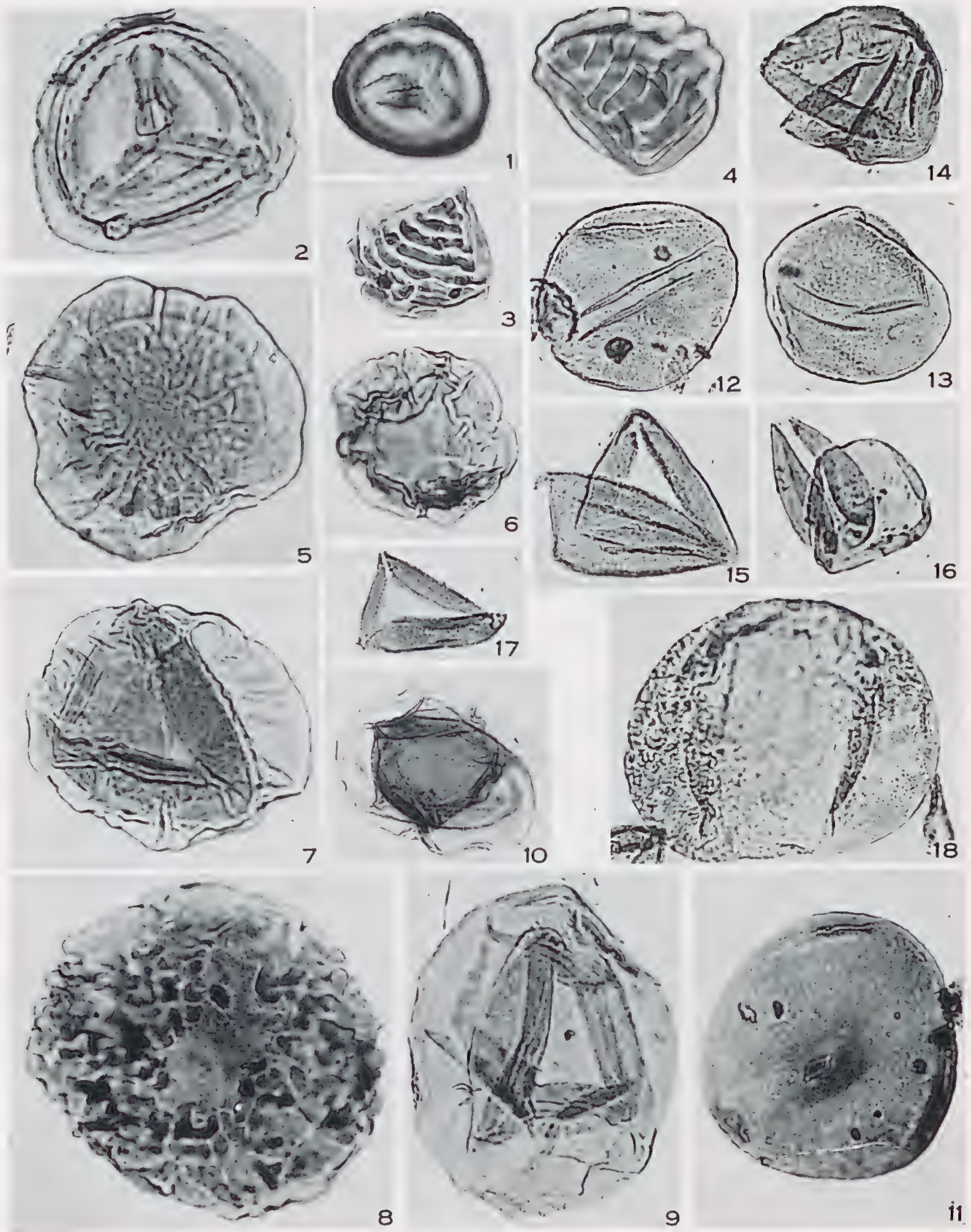


PLATE 5



## PLATE 6

FIG. 1. *Alisporites lowoodensis* de Jersey. Median focus (x 1,000). S. 1274: 29·0, 111·1.

FIG. 2. *Alisporites* sp. cf. *A. similis* (Balme) Dettmann. Median focus (x 1,000). S. 1242: 38·8, 92·0.

FIG. 3. *Podocarpidites* sp. cf. *P. ellipticus* Cookson. Median focus (x 750). S. 1223: 29·0, 96·5.

FIGS 4-6. *Vitreisporites pallidus* (Reissinger) Nilsson.

Figs 4, 5. S. 1284: 28·6, 101·7. Fig. 4. Proximal focus (x 1,000). Fig. 5. Distal focus (x 1,000).

Fig. 6. Median focus, trisaccate form (x 1,000). S. 1253: 32·8, 102·8.

FIGS 7, 8. *Indusiisporites parvisaccatus* (de Jersey) de Jersey.

Fig. 7. Distal focus (x 750). R22/5: 42·6, 111·7.

Fig. 8. Lateral orientation (x 750). R22/5: 42·3, 80·2.

FIGS 9, 10. *Podosporites* sp.

Fig. 9. Distal focus (x 1,000). R25/3: 45·8, 85·1.

Fig. 10. Slightly off-polar proximal focus, showing cappa ornament (x 750). S. 1275: 41·9, 93·8.

FIGS 11, 12. *Perinipollenites elatoides* Couper.

Fig. 11. Median focus, showing split in central body (x 1,000). R27/3: 31·1, 81·8.

Fig. 12. Median focus, showing split in central body (x 750). R27/3: 37·8, 97·1.

FIGS 13, 14. *Classopollis classoides* (Pflug) Pocock & Jansonius, 1961.

Fig. 13. Lateral view, showing hair-like processes at proximal pole, projecting from triangular area, and equatorial band of thickening (x 1,000). S. 1242: 32·9, 99·3.

Fig. 14. Tetrad (x 500). R26/3: 28·9, 117·8.

FIG. 15. *Classopollis simplex* (Danzé-Corsin & Laveine) comb. nov. Median focus (x 1,000). S. 1253: 29·1, 91·9.

FIG. 16. *Michrystridium* sp. (x 1,500). S. 1242: 38·9, 92·0.



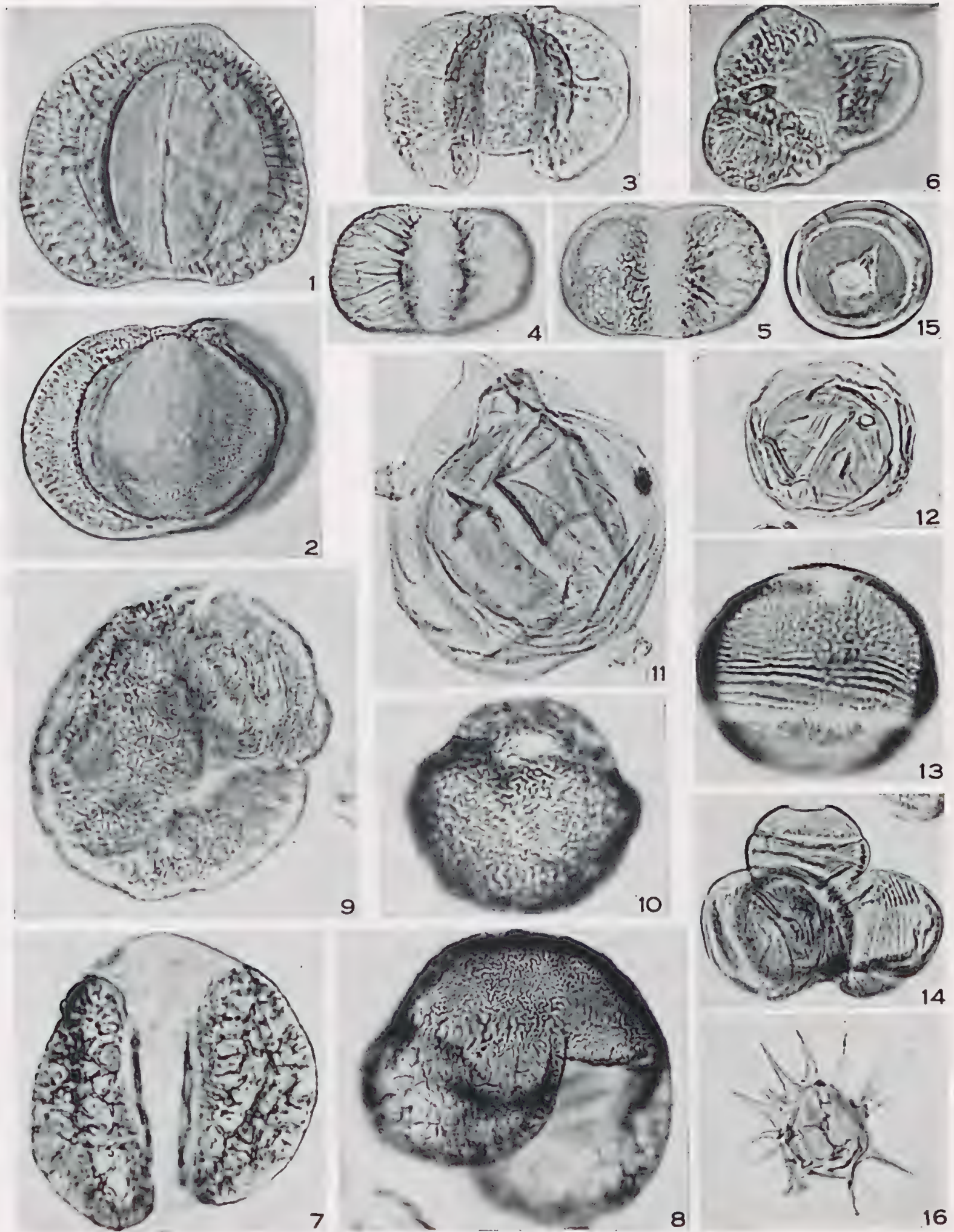


PLATE 6







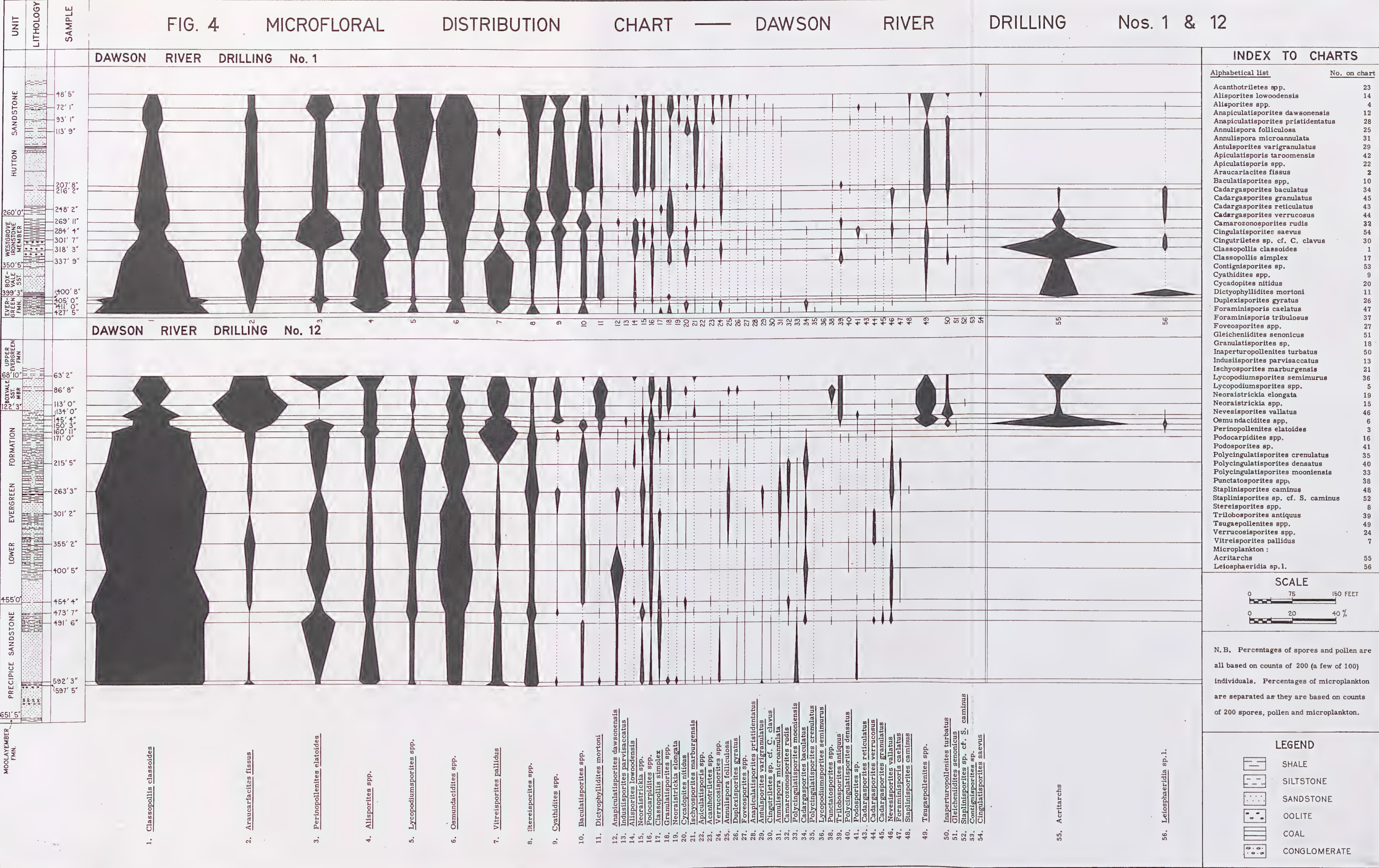








FIG. 5 MICROFLORAL DISTRIBUTION CHART — DAWSON RIVER DRILLING No. 6



SCALE



N. B. Percentages of spores and pollen are all based on counts of 200 (a few of 100) individuals. Percentages of microplankton are separated as they are based on counts of 200 spores, pollen and microplankton.

SHALE  
OOLITE

LEGEND

SILTSTONE  
COAL

SANDSTONE  
CONGLOMERATE

























QUEENSLAND  
DEPARTMENT OF MINES

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GEOLOGICAL SURVEY OF QUEENSLAND  
(J. T. Woods, Chief Government Geologist)

PUBLICATION No. 340  
PALAEONTOLOGICAL PAPERS, No. 16

# DEVONIAN CORALS FROM UKALUNDA

by  
D. HILL and J. S. JELL  
(University of Queensland)



BRISBANE  
1969







# DEVONIAN CORALS FROM THE UKALUNDA DISTRICT, NORTH QUEENSLAND

by J. S. Jell and D. Hill  
Department of Geology and Mineralogy  
University of Queensland

## ABSTRACT

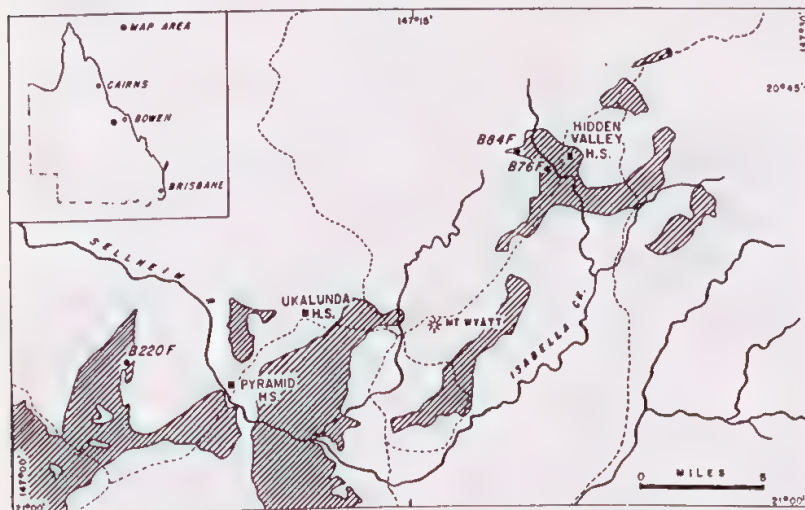
Small coral faunas consisting of species of *Metriophyllum?*, *Cyathophyllum* (*Cyathophyllum*), *Ceratophyllum*, *Gurievskiella*, *Temnophyllum?*, *Plasmophyllum* (*Plasmophyllum*), *Rhizophyllum*, *Calceola*, *Favosites*, *Squameofavosites*, *Thamnopora?*, *Cladopora*, *Alveolites*, *Pseudoplasmopora*, and *Aulopora*, are described; five of the species are new.

The age of the faunas is concluded to be probably Couvinian. A discussion of the family Cyathophyllidae with particular reference to Australian members is included.

## INTRODUCTION

The Devonian Ukalunda Beds outcrop in the southwestern portion of the Bowen 1:250,000 Sheet area, around the northern end of the Anakie Structural High, south of the Siluro-Devonian Lolworth granitic axis of uplift. Upper Devonian terrestrial strata are continuous westward and southwestward into the Drummond Basin, but there is as yet no proof that the older marine Devonian is continuous along the western flank of the Anakie Structural High with the marine Dunstable Beds of the Drummond Basin.

Many of the corals described in this paper were collected by the joint field parties of the Bureau of Mineral Resources and Geological Survey of Queensland during their mapping of the Bowen Basin and its margins in 1961 and 1962 (Malone *et al.*, 1966). Others were collected by similar parties in 1966 and 1967 and the remainder in 1966 by Dr. J. A. Talent of the Geological Survey of Victoria, to whom we are indebted for the gift of his material. The localities from which the collections were made are shown by their field numbers in text-figure 1. Preliminary identifications of the 1961 and 1962 coral collections were made by D. Hill and recorded by Malone *et al.* (1966) and preliminary identifications of the 1966 collections, also by D. Hill, were made in unpublished reports.



TEXT-FIGURE 1. Map showing the Ukalunda Beds (shaded) and the localities of the coral collections from the Ukalunda district, north Queensland.

Corals from Ukalunda were first recorded when a small collection made by J. H. Reid (1929) was named by Whitehouse (1929) and subsequently discussed by Reid (1930). The stratigraphy of the beds containing the corals has been established by Malone *et al.* (1966).

## AGES SUGGESTED BY THE CORAL FAUNAS

The present collections are from two stratigraphic units: the Ukalunda Beds, and conglomerate at the base of the overlying Drummond Group. The corals in the latter are found in limestone pebbles in the conglomerate and it is assumed that the pebbles were derived from an older limestone.

Collection B76F.—Ukalunda Beds in Mary Creek, "Hidden Valley", 8 miles north-northeast of Mt Wyatt, Ukalunda district, southwestern part of the Bowen 1:250,000 Sheet area, north Queensland.

*Cyathophyllum* (*Cyathophyllum*) *sentum* sp. nov.  
*Ceratophyllum* sp. A  
*Gurievskiella* *talenti* sp. nov.  
*Temnophyllum?* sp.  
*Plasmophyllum* (*Plasmophyllum*) *magnivesiculosum* sp. nov.  
*Rhizophyllum* *ukalundense* sp. nov.  
*Calceola* *sandalina* (Linnaeus)  
*Squameofavosites* *bryani* (Jones)  
*Squameofavosites* *nitidus* (Chapman)  
*Thamnopora?* sp.  
*Cladopora* sp.  
*Alveolites* sp. cf. *A. stamineus* (Hill)  
*Pseudoplasmopora* sp. cf. *P. gippslandica* (Chapman)

Of the rugosan species only *Calceola sandalina* has been described previously; its known range is Couvinian and Givetian, but it has been reported (without supporting illustrations of thin sections) from the Zlichovian (upper Emsian) of Czechoslovakia and from Emsian limestones in France and Szechuan, China. The ranges of genera are discussed below in the systematic section and are summarized as follows. *Cyathophyllum* (*Cyathophyllum*), as interpreted herein, has a known range of Eifelian and Givetian, with possible representatives in the Emsian of Nevada. *Ceratophyllum*, so far as is known at present, occurs in the upper Eifelian *Calceola* beds of the Urals and in the lower Givetian in Poland. *Gurievskiella* has a known range of Siegenian to Eifelian. The doubtful reference to the Middle Devonian *Temnophyllum* should carry little weight. *Plasmophyllum* (*Plasmophyllum*) has a range of Lower and Middle Devonian; the species *P. (P.) magnivesiculosum* is morphologically similar to *P. (P.) salairicum* (Peetz) from the Siegenian? upper Krekov horizon of the Salair and from an equivalent horizon in the central Taimyr. *Rhizophyllum* ranges from the upper Wenlockian to the lower Eifelian; *R. ukalundense*, with its wide peripheral stereozone, is closest morphologically to *R. mongolicum* Spasskiy from the Eifelian of the Mongolian Altai.



Of the Tabulata, the two species of *Squameofavosites* have a range of Siegenian to Couvinian?; the *Alveolites* species is not unlike *A. stamineus* from the Emsian or Couvinian? Murrindal Limestone of Victoria. *Pseudoplasmodora* in the USSR ranges from the Wenlockian into the Ludlovian and in Victoria *P. gippslandica* is probably Siegenian.

Summing up, the age of the fauna would appear to be within the range Siegenian to Givetian, with Couvinian as the favoured probability though the Tabulata collectively suggest an early Devonian age.

Collection B84F.—Ukalunda Beds, 2 miles slightly north of west of Hidden Valley homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 Sheet area, north Queensland.

*Cyathophyllum* (*Cyathophyllum*) *pannosum* sp. nov.  
*Ceratophyllum* sp. A?

*Gurievskiella talenti* sp. nov.

*Plasmophyllum* (*Plasmophyllum*) *magnivesiculosum* sp. nov.

*Favosites* sp. cf. *F. goldfussi* d'Orbigny

*Squameofavosites bryani* (Jones)

*Thamnopora*? sp.

*Cladopora* sp.

*Alveolites* sp. cf. *A. stamineus* Hill

*Aulopora* sp.

This fauna is so similar to the one discussed above, that it must be of approximately the same age — probably Couvinian; this conclusion is supported by *Favosites* sp. cf. *F. goldfussi*.

Collection B220F.—Ukalunda Beds 4.75 miles slightly north of west of the Pyramid homestead, Ukalunda district, southwest part of the Bowen 1:250,000 Sheet area, north Queensland.

*Metriophyllum*? sp. A

*Metriophyllum*? sp. A indicates a Devonian age for the beds containing it.

Collection from the limestone pebbles in the conglomerate at the base of the Drummond Group (i.e. probably in the Mt. Wyatt Beds), 2.75 miles west of the Pyramid homestead, Ukalunda district, southwestern part of Bowen 1:250,000 Sheet area, north Queensland.

*Phacellophyllum* sp. A

*Protomacgeea* sp. A

*Acanthophyllum* sp.

*Tryplasma* sp.

*Calceola* sp.

*Alveolites* sp.

*Phacellophyllum* ranges through the Middle and Upper Devonian, but the species is the same as one not yet described from the Couvinian part of the Chinaman Creek Limestone Member of the Broken River Formation, north Queensland. *Protomacgeea* occurs in the Eifelian of Poland; in the Couvinian part of the Chinaman Creek Limestone Member of the Broken River Formation, north Queensland; and in the Givetian Mt. Frome Limestone of New South Wales (Wright, *in litt.*). *Acanthophyllum* is characteristic of the range upper Emsian to Givetian; *Tryplasma* has a

Silurian to Couvinian range, but the species is very close to a specimen from the Couvinian Loomberah Limestone; the *Alveolites* species is close to the Emsian or Couvinian? *A. stamineus*. Thus the age of the limestone from which these pebbles were derived was almost certainly Couvinian.

In this as in previous papers on Australian coral faunas by Hill (*e.g.* 1950), we use the sequence in the south of the Dinant Basin as our standard of reference for the Devonian, so that we subdivide the Middle Devonian into the Couvinian and Givetian, rather than into the Eifelian and Givetian Stages.

If the base of the Eifelian be taken as urged by Erben (1962) at the horizon of the incoming of the goniatites *Gyroceratites gracilis* and *Anarcestes lateseptatus*, it would seem (from his review) to lie in the Eifel between the Heisdorf and the Lauch Beds, and on the south flank of the Dinant Basin between Cola and Co2a, within the range Colb and Colc. Thus if Erben proves to be right, and his recommendation be followed, the term Couvinian would imply a slightly longer interval of time than the term Eifelian, and the German Emsian would presumably have lasted longer than the Belgian Emsian. The Russian 'Eifelian', as explained by Rzhonsnitskaya (1962), would seem to be better equated with the longer Couvinian than with the shorter Eifelian, and might indeed have begun slightly earlier still. According to Erben, in Czechoslovakia the top of the Zlichovian (Zlichov Limestone) is upper (German) Emsian, and the overlying Daleje Shale or Trebotov Limestone contains *G. gracilis* and is therefore Eifelian. Rzhonsnitskaya correlated the Zlichovian with the *Paraspirifer gurievskiensis* beds at the base of the Russian 'Eifelian'.

#### SYSTEMATIC DESCRIPTIONS

For diagnoses of generic and suprageneric taxa see Hill (1956b), and Hill & Stumm (1956). The type and figured specimens described herein are housed in the University of Queensland Department of Geology and catalogued with UQF numbers.

|          |                                       |
|----------|---------------------------------------|
| Order    | RUGOSA Edwards and Haime, 1850        |
| Suborder | STREPTELASMATINA Wedekind, 1927       |
| Family   | METRIOPHYLLIDAE Hill, 1939            |
| Genus    | METRIOPHYLLUM Edwards and Haime, 1850 |

*Metriophyllum*? sp. A

Pl. 1, figs. 1-5

*Material*:—UQF53341-8 on the one slide, with sections through eight corallites, from Ukalunda Beds at B220F (see text-fig. 1); Devonian.

*Description*:—Corallites small, solitary, cylindrical to subcylindrical except possibly at their apical ends where they may show an early turbinat stage. Their external characters are not known; sections suggest that they are no more than 5mm in height. The corallite wall is thick, 0.2-0.25mm. The transverse sections are slightly oval; the longer and shorter diameters varying from 3.75 to 4.25mm and 2.5 to 3.2mm respectively. There are 12 to 14 major septa arranged with bilateral symmetry about the conjoined counter and cardinal septa. The major septa are thick, slightly expanded at



their axial ends where they join to form a solid axial pillar. In parts of the corallite, adjacent septa are in contact for most of their length. The septa carry flanges that are horizontal or slightly declined towards the periphery and that have upturned edges. In places small protuberances occur at the periphery between the major septa; these may be short minor septa but are possibly the cut edges of the flanges where they join the corallite wall. No horizontal skeletal elements show in the longitudinal sections available.

*Remarks:*—This north Queensland form is tentatively included in *Metriophyllum*. It differs from the type species of that genus (*M. bouchardi* Edwards and Haime) in that the septa are much thicker, and the axial pillar is composed of the fused ends of the septa without additional nonseptal sclerenchyme. Also, its counter and cardinal septa appear to be joined, with the median dark line (as seen in transmitted light) being continuous from one to the other through the axial pillar, a character not recognised in other species referred to *Metriophyllum*.

Family CYATHOPHYLLIDAE Dana, 1846  
[= Zaphrentidae Edwards & Haime, 1850; Zaphrentidae Moore & Jeffords, 1945; Zaphrentidae Minato, 1943; Heliophyllidae Nicholson in Nicholson & Lydekker, 1889; Sterictophyllidae Pedder, 1965; ?Bethanyphyllidae Stumm, 1949]

*Type Genus:*—*Cyathophyllum* Goldfuss, 1826.

*Diagnosis:*—Solitary or colonial Rugosa; corallites typically large with inverted conical or bell-shaped calices with narrow, or wide and flat, or everted margins and a low median boss. Septa numerous, long, straight except for possible slight curvature in the axial region, smooth or carinate with either yardarm or zigzag carinae, arranged either radially or bilaterally. Cardinal fossula typically indicated only by shortness of cardinal septum. Trabeculae not large, elliptically or rectangularly expanded laterally, their fibres diverging from their axes at a relatively low angle. Tabularium typically wide with domed tabularial floors that may flatten or sag axially when major septa are withdrawn from the axis, and that typically consist of numerous tabellae; dissepimentarium commonly wide, consisting of numerous, small, rather globose dissepiments.

*Remarks:*—The comprehensive study of the cyathophyllids of the Eifel by Birenheide (1963) has supported the previous view of Lecompte (1953) and Hill (1956b) in the grouping of *Cyathophyllum* Goldfuss, *Heliophyllum* Dana, and *Zaphrentis* Rafinesque & Clifford in the one family distinct from the Ptenophyllidae [Acanthophyllidae of some authors]. As his study established the taxonomic position of *Cyathophyllum*, and as Cyathophyllidae Dana, 1846 has priority over Zaphrentidae Edwards & Haime, 1850, Birenheide's restoration of the family group name of Cyathophyllidae is justified.

*Cyathophyllum* entered at the beginning of the Devonian and persisted throughout the Lower and Middle Devonian. Its range is discussed in detail later.

*Heliophyllum*, except for its characteristic, long, slender widely spaced yardarm carinae, closely

resembles *Cyathophyllum* in internal structure; however, it may show a more bilateral arrangement of the septa that may frequently be dilated in the tabularium. It is best known from the Middle Devonian of the Atlantic province of North America where it entered in the lowermost Eifelian in the Edgecliff Member of the Onondaga Limestone (Oliver, 1954). It has not been recorded from the Pacific province of the United States, but Smith (1945, p. 26) considered *H. parvulum* Whiteaves, 1891, from the Upper Devonian of the Mackenzie River, northwest Canada to belong to it. Forms very similar to eastern North American species have been described from the Middle Devonian of northwest Africa (Le Maitre, 1952). Middleton (1959) referred a new species from the Middle Devonian of south Devonshire to *Heliophyllum*, but its septa are considerably dilated and very ragged in appearance owing to the shortness of the carinae and it may not be congeneric with *H. halli*. *Heliophyllum* has also been described from the Eifelian of Germany (Haller, 1936; Birenheide, 1963). In Russia the genus is known from the Middle Devonian of the Urals (Soshkina, 1941, 1949, 1952; Spasskiy, 1959), Armenia (Soshkina, 1952), Kuzbas, Altai and Salair (Bulvanker, 1958; Zheltonogova and Ivaniya, 1961; Ivaniya, 1965; *H. aiense* Soshkina as figured by these authors shows thicker, shorter, and more closely spaced carinae than the type species). The specimen figured as *Heliophyllum* sp. by Ivaniya (1965, p. 99, pl. 96, fig. 401) from the Famennian Kosoutsov Beds of the Kuzbas, shows occasional carinae, but in the absence of a longitudinal section its true generic affinities are doubtful.

Hill (1954, p. 110, pl. 7, figs. 12a-c) described a new species *Heliophyllum pinguiseptatum* from the Emsian (Talent, 1965) Liptrap Formation of Waratah Bay, Victoria. This is characterized by the extensive dilation of the major septa in the tabularium, and by having diamond-shaped carinae and not the thin long straight carinae typical of the North American species. From the Cooper's Creek Formation of the Tyers area, Gippsland, Victoria, Philip (1962, p. 175, pl. 23, figs. 1, 5) equated a specimen with Hill's species while pointing out that it differed in not showing any septal dilation in the tabularium.

The age of the Cooper's Creek Formation is the subject of current discussion. Philip (1965) stated that the range permitted by the conodont fauna was upper Gedinnian to the top of lower Emsian; the absence of *Polygnathus* led him to discount the early Emsian age and he preferred the range late Gedinnian to early Siegenian. Philip & Pedder (1967a) considered that the Cooper's Creek *Eognathodus sulcatus* Philip was of limited range in Nevada and Australia and confined to the early Siegenian. They therefore regarded the Cooper's Creek Formation as early Siegenian, and correlated with it, as early Siegenian, the Lilydale Limestone and the Loyola Limestone. Talent (1965, 1967) on the other hand considers a probable late Siegenian age is indicated for the Cooper's Creek Formation by the regional stratigraphy using graptolites, tentaculites, and brachiopods and he correlated the Loyola Limestone with it. He considers the Lilydale Limestone to be Emsian, possibly lower Emsian, on its stromatoporoid, coral, gastropod, bivalve, and



brachiopod faunas. Until the ranges of the relevant conodont, coral and brachiopod species are more securely established; we regard the Cooper's Creek Formation and the Loyola Limestone as probably Siegenian, and the Lilydale Limestone as within the range Siegenian-Emsian.

The Australian *Heliophyllum* is probably the earliest of the genus and may indeed represent a separate subgenus. *Peripaedium poshiense* Fontaine (1966, p. 55, pl. 1, fig. 6; pl. 3, figs. 3-5; pl. 5, figs. 6, 7; pl. 6, fig. 1; pl. 15, fig. 1) from the upper Couvinian to lower Givetian Poshi Beds of Yunnan shows diamond-shaped carinae similar to those of the Victorian species.

Stumm (1949) proposed *Heliophylloides* for species he considered intermediate between those of *Zaphrentis* and *Heliophyllum*. Oliver (1960, p. 17) doubtfully included *Heliophylloides* in *Zaphrentis*, but Stumm (1964) referred *Cyathophyllum brevicorne* Davis, 1887, the type species of *Heliophylloides*, to *Heliophyllum venatum* Hall. As it had a well developed dissepimentarium, Stumm included it in the synonymy of *Heliophyllum*. He restricted *Zaphrentis* to those forms with the septal and tabularial characters of *Heliophyllum*, but lacking a well developed dissepimentarium. Stumm (1964) selected a neotype for *Z. phrygia*, but figured only the exterior of it.

In size, abundance of septa, width of dissepimentarium and domed nature of the tabularial floors, the solitary North American Middle Devonian *Tortophyllum* Sloss, 1939, appears to be a cyathophyllid. However, the dilation of the septa in narrow concentric zones within the dissepimentarium, with the thickening spreading out onto the dissepiments, is not common in the family. In addition the common swirling of the septa at the axis, and the markedly biserial tabularium, consisting of a periaxial series of flat horizontal tabellae sharply delineated from a steeply arched axial series of convex tabellae, suggest that at least *T. cysticum* Winchell, 1866, the type species, is generically distinct from the other solitary cyathophyllids. Other forms placed by subsequent authors in this genus do not show all these characters and display features that liken them to other groups. *Tortophyllum milleri* Pitrat (1962, p. 1158, pl. 158, figs. 7-10, especially figs. 7, 8) is difficult to distinguish from the Australian forms referred herein to *Cyathophyllum* (*Radiophyllum*).

While we lack complete knowledge of the internal structure of the lectotype of *Cyathophyllum robustum* Hall, 1876, the type species of *Bethanyphyllum* Stumm, 1949, the true generic and family affinities of this genus will remain questionable. Following Hill (1956b) and others, it is only doubtfully included in the Cyathophyllidae.

*Moravophyllum ptenophylloides* Kettnerova, 1932, the type species of *Moravophyllum* Kettnerova, differs from European species of *Cyathophyllum* by its pronounced bilateral form in transverse section, and by the dilation of the septa in the cardinal quadrants of its tabularium in the early growth stages. These two features suggest affinity with the ptenophyllids, while the second is well known in the Silurian lycophyllinids.

This genus has been recorded only from the Givetian of Europe.

*Distribution*:—Cosmopolitan, Devonian.

#### Genus CYATHOPHYLLUM Goldfuss, 1826

*Synonymy*:—See subgenera *C.* (*Cyathophyllum*), *C.* (*Radiophyllum*), *C.* (*Peripaedium*), *C.* (*Sterictophyllum*).

*Type Species* (by subsequent designation of Dana, 1846, p. 183):—*Cyathophyllum dianthus* Goldfuss, 1826, from the Middle Devonian, Eifel, Germany.

*Diagnosis*:—Solitary or colonial Cyathophyllidae; septa numerous, long or variously withdrawn from the axis, smooth or carinate; carinae trabeculate, alternate to subopposite; fossulae inconspicuous; cardinal septum commonly slightly shorter than the other major septa. Tabularial floors domed, becoming flat-topped or sagged axially when major septa are withdrawn; dissepimentarium wide, composed of numerous globose dissepiments of moderate size.

*Remarks*:—Birenheide (1963), by following Lang, Smith, & Thomas (1940, p. 44) in accepting *C. dianthus* Goldfuss as the type species of the genus [not *C. dianthus* Lonsdale non Goldfuss as did Wedekind (1924, p. 35)] and by choosing a neotype for the type species (considering its lectotype to be lost), paved the way for a clearer and more precise definition of the taxon. Additionally his work focussed attention on the great variability that occurs within its species in the Middle Devonian of the Eifel. This variation is excellently illustrated in a paper by Haller (1936). Considering this variability, Birenheide concluded from the study of extensive collections that the species may be grouped in two subgenera differentiated mainly on the completeness of the tabulae. *C.* (*Cyathophyllum*) includes all forms in which the septa are variously withdrawn from the axis and the central part of the tabularial floors consists of relatively large domed, horizontal or sagged tabellae. *C.* (*Peripaedium*) encompasses those characterized by long septa extending to the axis, and by domed tabularial floors consisting essentially of small globose tabellae.

A study of the Australian species in the light of Birenheide's work has shown that the morphologies of both *C.* (*Cyathophyllum*) and *C.* (*Peripaedium*) are represented in Australia. In addition, two other morphological groups are recognized. We regard them as congeneric with the Eifel forms, but consider it useful to retain them as separate subgenera of *Cyathophyllum*, i.e. *C.* (*Radiophyllum*) and *C.* (*Sterictophyllum*). The morphology of *C.* (*Radiophyllum*) has been recognized outside Australia, but the other is as yet known only from southern New South Wales and Victoria.

*Distribution*:—Europe, Emsian to Givetian; USSR, Gedinnian to Givetian; Asia, Middle Devonian; Australia, Lower Devonian and Couvinian; North America, Emsian to Givetian.



Subgenus CYATHOPHYLLUM  
(CYATHOPHYLLUM) Goldfuss, 1826

*Type species*:— as for genus.

*Diagnosis*:—*Cyathophyllum* with septa variously withdrawn from the axis, commonly carinate with short, alternate or subopposite carinae, slightly dilated or retiform towards the periphery; tabularial floors slightly sagged, or horizontal centrally, consisting of a periaxial series of small convex tabellae declined axially and an axial series of flat or slightly arched tabellae which in places may form a slight central elevation.

*Remarks*:—*C. (Cyathophyllum)* is best known from the Eifel where it entered in the late Eifelian and became extinct by the late Givetian (Birenheide, 1963). The only other possible representatives of the group in Europe are two species described by Penecke (1894) from the *Barrandei* beds (Eifelian or Givetian?) of the Graz district as *Cyathophyllum ungeri* (pl. 8, figs. 9, 10) and *C. graecense* (pl. 8, figs. 14, 15). The figures given by Penecke are not adequate for reliable generic designation.

The subgenus has not yet been recognised in the Devonian faunas of northwest Africa and eastern North America; in these *Heliophyllum* is the dominant cyathophyllid. In the Great Basin of western U.S.A. several of the Lower Devonian (upper Emsian) forms from the lower 500 feet of the Nevada Limestone, described by Stumm (1937) as *Grypophyllum* and '*Cyathophyllum*', may prove to be representatives of the group when median longitudinal sections are available. Similarly, the generic affinities of two specimens figured as *Cyathophyllum* sp. by Merriam (1940, pl. 12, figs. 2, 4) from the '*Spirifer*' *pinionensis* Zone [Emsian of Johnson (1966); upper Emsian of Clark & Ethington (1966)] are doubtful as no longitudinal sections have been figured. However, the cerioid *Prismatophyllum flexum* Stumm (1938, pl. 58, figs. 6a-d; pl. 59, figs. 6a-c) from the Eifelian middle part of the Nevada Limestone is sufficiently similar to *C. (C.) dianthus* in external form, particularly in its mode of increase, septal characters, and arrangement of the tabularium, for it to be considered a member of the subgenus. The dissepiments and their arrangement are a little different from those of the Eifel species in that they are slightly smaller, more regular in size, and arranged in more everted calical platforms. They are more phillipsastraeoid, and are especially like those in *Radiastrea arachne* Stumm.

The holotype of the solitary *Ceratophyllum schandiense* Zheltonogova in Zheltonogova & Ivaniya (1961, pl. D-54, fig. 3; pl. D-55, fig. 1) from the lower Eifelian Shanda beds of the Salair, USSR, is referable to *C. (Cyathophyllum)*. *Bethanyphyllum maximum* Spasskiy (1965, pl. 3, figs. 1, 2) from the Eifelian of the Dzhungarian Alatau, USSR, may be doubtfully placed in *C. (Cyathophyllum)*. *Cyathophyllum flexuosum* Sun (1958, pl. 12, figs. 1-2) from the Frasnian of Hunan, China, is not interpretable without a longitudinal section.

*C. (C.) chillagoense* Etheridge (1911, pl. D, figs. 1, 2) from an unknown horizon in the Chillagoe Limestone appears to us to be very close to *C. (C.) dianthus*. Its age was considered Silurian by Etheridge, but this must now be questioned. Etheridge assigned the Silurian age on the occurrence of *Halysites* in the Chillagoe Limestone, but whether this came from the same outcrop as *C. (C.) chillagoense* is unknown.

The only other known species of *C. (Cyathophyllum)* are described herein from the probably Couvinian Ukalunda Beds of north Queensland.

*Distribution*:—Europe, Eifelian and Givetian; Nevada, Emsian? and Eifelian; the Salair, Asiatic Russia, Eifelian; Australia, Couvinian.

*Cyathophyllum*  
(*Cyathophyllum*) *sentum* sp. nov.

Pl. 1, figs. 6-12

*Derivation of name*:— Latin, *sentus* = thorny — appearance of septa.

*Holotype*:— UQF52710, from B84F, Ukalunda Beds in Mary Creek, 'Hidden Valley', 8 miles north-north-east of Mt. Wyatt, Ukalunda district, southwestern part of the Bowen 1:250,000 Sheet area, north Queensland; probably Couvinian.

*Diagnosis*:— Solitary *C. (Cyathophyllum)* with septa considerably withdrawn from the axis, slightly dilated in the inner dissepimentarium, possessing alternate carinae with spinose outer edges; septa of both orders occasionally discontinuous, periaxial tabellae small, convex; axial tabellae large, flat or slightly elevated with narrow periaxial trough and slight axial depression.

*Description*:— The specimens are all single, ceratoid to subcylindrical corallites, variously abraded, some showing a few rejuvenescence rims but never any evidence of offsets. Their adult diameter is commonly between 18 and 30mm; however, that of one specimen is 45mm. They seem to be thin-walled with only a thin dark epithecal sheath surrounding a thicker fibrous layer. The calice is bell-shaped, but the axial pit has a horizontal or broadly domed floor; the platform is horizontal and comparatively narrow with a sharp rim.

The septa are radially arranged; in some corallites the presence of a fossula is suggested by the shortness of a major septum which is perhaps the cardinal septum. The major septa number 34 to 38 and vary in length from only a little longer than the minor septa (when the tabularium is devoid of septa) to twice the length of the minor septa when they almost reach the axis. They are commonly slightly dilated in the dissepimentarium, thin at the periphery and at the tabularial boundary. In the region of thickening they carry prominent zigzag carinae which are short and usually almost as thick as the septum from which they arise. These carinae are derived from the lateral extension of the fibres of the trabeculae and the slight divergence of the trabeculae from the median plane of the septum. Along the distal edge of a carina there is commonly a series of short, closely spaced small



spines (vepreculae of Pedder, 1966). In forms with the septa projecting only a short way into the tabularium the septal ends are thin and flexuose whereas in others they may be represented by discrete trabeculae. In one specimen (UQF52708) the major septa extend almost to the axis and the septal ends are dilated and irregular, many intertwining. The minor septa are variously developed; in most of the forms they are straight, continuous, slightly less dilated than the major, and commonly carinate; however, in places, they are not dilated, but become zigzag, flexuose, or even discontinuous, so that the dissepiments of neighbouring loculi inosculate, and the septa may be represented only by short crests in the angle between two adjoining dissepiments.

The tabularium is usually slightly more than half the diameter of the corallites and has flat or slightly arched tabularial floors which tend to be sagged axially when the septa are withdrawn. The tabellae are developed in two series; the periaxial series is of small, globose, axially declined, crowded plates; the axial series is of more regularly arranged, larger tabellae that are almost horizontal but sometimes slightly arched with their central region sagged. In vertical section, several of the specimens show, at various levels in the corallite, one or a few tabularial floors considerably thickened due to deposition of fibrous material on the distal surfaces of the tabellae.

The dissepimentarium is wide, composed of numerous globose plates that are horizontal or slightly inclined at the periphery and steeply inclined at the tabularial boundary. Occasionally large blister-like (lonsdaleoid) dissepiments may replace those of the normal type at the periphery.

*Remarks:*— In transverse section *C. (C.) sentum* with its slightly dilated septa and frequent short zigzag carinae closely resembles species of *Keriophyllum* Wedekind. Birenheide (1963) has shown that *K. heiligensteini* Wedekind, the type species of *Keriophyllum*, is synonymous with *C. (Peripaedium) turbinatum*, which is the type species of *C. (Peripaedium)*. Of the five species Wedekind (1924) referred to *Keriophyllum*, all but *K. complicatum* Wedekind [= *C. (Cyathophyllum) spongiosum* (Schultz)—Birenheide (1963)] have tabularia typical of *C. (Peripaedium)*, whereas the tabularium of *C. (C.) spongiosum* is of the type seen in *C. (C.) dianthus*. Similarly, Birenheide has referred some of Haller's (1936) species of *Keriophyllum* to *C. (Cyathophyllum)* and some to *C. (Peripaedium)*, thereby placing greater taxonomic value on the tabularial characters than on septal features in these taxa. We agree with this, and therefore assign the north Queensland species with its wide axial tabellae to *C. (Cyathophyllum)*, although its septal features suggest *C. (Peripaedium)*. It differs from *C. (Cyathophyllum) spongiosum* in that it is considerably smaller, has a narrower dissepimentarium but a proportionally wider tabularium, and has fewer septa which do not become retiform at the periphery, and are further withdrawn from the axis.

*C. (C.) sentum* closely resembles *Keriophyllum* sp. F. from the Givetian middle Presqu'ile Formation of

the Mackenzie district, Canada, figured by McLaren in McLaren, Norris & McGregor (1962, pl. 4, figs. 1-4), but is distinguished by its slightly less dilated septa and more complete axial tabellae. Of the overseas species, the Queensland form is perhaps closest to *C. (Cyathophyllum) schandiense* (Zheltonogova in Zheltonogova & Ivaniya, 1961) from the Eifelian of the Salair, USSR, which is somewhat doubtfully referred to *C. (Cyathophyllum)* herein. It is distinguished from the Siberian form by the less distinct boundary between the tabularium and dissepimentarium.

*Cyathophyllum*  
(*Cyathophyllum*) *pannosum* sp. nov.  
Pl. 2, figs. 10-12

*Derivation of Name:*— Latin, *pannosus* = ragged.

*Holotype:*— UQF52798, from B84F, Ukalunda Beds 2 miles slightly north of west of Hidden Valley homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 Sheet, north Queensland; probably Couvinian.

*Diagnosis:*— Moderately large solitary *C. (Cyathophyllum)* with septa dilated and ragged in the inner dissepimentarium; axial ends of major septa slightly dilated, consisting of discrete monacanth diverging laterally from the median plane, and considerably withdrawn leaving a wide axial space. Tabularium composed of an outer series of convex tabellae and an axial series of flat tabellae.

*Description:*— The three specimens on hand are abraded, single, moderately large corallites whose juvenile stages are not preserved. They are cylindrical or subcylindrical with several rejuvenescences and range from 17 to 30mm in diameter and up to 70mm in height. The corallite wall is 0.1 to 0.15mm thick consisting of an outer thin dark epithelial sheath and an inner thicker zone of fibres normal to the outer layer. The calices are not preserved but from longitudinal sections they seem to have been flat-bottomed and widely bell-shaped.

The septa number 35 x 2 to 39 x 2 in adult stages, and are radially arranged with the two orders clearly differentiated. In the inner dissepimentarium they are considerably thickened and have ragged surfaces due to the spasmodic development of short stout carinae; they thin axially and peripherally. In the outer dissepimentarium they become slightly zigzag in places but rarely are there any carinae present at the angles. The minor septa terminate at the tabularial boundary and the major extend a third of the way across the tabularium. In the tabularium the septa are thin and straight, except at their axial extremities which are slightly swollen and developed into two vertical series of stout monacanth that diverge laterally from the median plane of the septum. These axial modifications of the septa produce a pronounced boundary to the wide axial space.

The tabularium is wide, one half to two-thirds of the diameter of the corallite, and differentiated into two zones. The axial region, corresponding to the axial space free of septal ends, contains closely spaced flat or slightly arched tabellae with some slightly sagged



axially. The outer region contains rather large globose interseptal tabellae declined axially at a moderate angle.

The dissepimentarium consists of numerous globose dissepiments that decrease in size axially. They are commonly horizontally based at the periphery, steeply inclined in the inner dissepimentarium, and almost vertical at the tabularial boundary.

*Remarks:*— The species shows similarities to both *C. (Cyathophyllum)* and *C. (Radiophyllum)*. The straight and fusiform septa are more like the thicker septa of *C. (R.) arborescens* (Hill & Jones) from the Lower Devonian at Mt. Etna, Queensland than those of the Eifel species of *C. (Cyathophyllum)*. On the other hand, the raggedness and occasional zigzag form of the septa in the dissepimentarium is common in *C. (Cyathophyllum)* and *C. (Peripaedium)*. The tabularium is of the *C. (Cyathophyllum)* type, without the prominent periaxial trough that is common in, and diagnostic of, *C. (Radiophyllum)*. The dissepimentarium, with the larger flatter dissepiments at the periphery, resembles that of the Mt. Etna *C. (R.) arborescens*. However, in view of the importance of the tabularial characters in this group, we have included the Ukalunda species in *C. (Cyathophyllum)*.

*C. (C.) pannosum* is distinguished from all the European representatives of the subgenus by its septal characters, wide axial space, and narrower dissepimentarium. It differs from *C. (C.) sentum* by its larger size, less carinate septa, wider tabularium, and the peculiar axial modification of its septa.

*Material:*— Three specimens from the type locality.

Subgenus CYATHOPHYLLUM  
(RADIOPHYLLUM) Hill, 1942b.

*Synonymy:*— *Stathmoelasma* Pedder, 1965, pp. 207-8.

*Type Species:*— *Entelophyllum arborescens* Hill & Jones (1940, p. 188, pl. 3, fig 5) from the Garra Formation (Siegenian?—Emsian) of Nora Creek, parish The Gap, near Molong, N.S.W.

*Diagnosis:*— *Cyathophyllum* with thin fusiform to slightly flexuose septa variously withdrawn from the axis and usually non-carinate; tabularial floors strongly elevated with a variably developed periaxial trough, axial tabellae wide, arched, with central part flattened or sagged.

*Remarks:*— As noted by Hill (1942b), its type species displays many similarities to both *Entelophyllum* and *Heliophyllum*. Considering the variation in the species of *Cyathophyllum* from the Eifel described by Birenheide (1963), we now believe *R. arborescens* shows a closer resemblance to *C. (Cyathophyllum)*, although the tabularium appears intermediate in type between that of *C. (Cyathophyllum)* and that of *Entelophyllum*.

Interpreting *Radiophyllum* from photographs, kindly lent to us by Dr. D. L. Strusz, of the holotype and topotypic material, we distinguish it from *C. (Cyathophyllum) dianthus* only by its growth form, its thin, straight and slightly fusiform septa that are

only rarely carinate, more elevated tabularial floors with a corresponding periaxial trough, its more globose periaxial tabellae, and its occasional development of lateral dissepiments. All are distinctions of degree and are not considered to be of generic significance. However, it is thought advisable to group the forms with the above morphology as the subgenus *C. (Radiophyllum)* which may have stratigraphic and phylogenetic significance.

The ages of the Garra faunas are currently under discussion. Philip & Pedder (1968) consider them to range from mid-Siegenian (mainly on the occurrence of the conodont *Spathognathodus transitans* Bischoff & Sannemann) to late Siegenian [largely on the occurrence of *Polygnathus linguiformis dehiscens* Philip & Jackson (1967) which they regard as more primitive than the Emsian *P. linguiformis* of Europe]. Strusz (1968) considered the overall aspect of the faunas to be Emsian.

Hill (1942b) referred several specimens from the Mt. Etna Limestone of central Queensland to *R. arborescens*. These specimens are slightly larger and have more elevated tabularial floors than the Garra material, and Strusz (*in* Pedder, 1965) regards them as not conspecific with the holotype. After studying additional material from Mt. Etna, we think that, apart from their slightly larger corallite diameters, the central Queensland forms are probably well within the range of variability of the Garra forms. Specimens that are probably conspecific with the Mt. Etna forms have been collected from the Martin's Well Limestone Member of the Broken River Formation, 'Pandanus Creek', north Queensland that one of us (J.S.J.) considers to have an Emsian coral fauna. Hill (1942d) compared specimens from the northern outcrop of the Garra Formation near Wellington with *R. arborescens*. All the above limestones are probably nearly coeval, within the range Siegenian to Emsian. Philip and Pedder (1968) considered the conodont *Icriodus pesavis* Bischoff & Sannemann to suggest a pre-Emsian age for the Mt. Etna Limestone.

Pedder (1965) referred four specimens, all of which were single corallites somewhat abraded, from the upper part of the Sulcor Limestone (Couvinian) of the Tamworth district, New South Wales, to a new species *Stathmoelasma amplum*, the type species of his genus *Stathmoelasma*. The internal structure of the Tamworth forms closely resembles that of *C. (R.) arborescens*, especially the larger forms from Mt. Etna. The Tamworth specimens are larger and contain many more septa than *C. (R.) arborescens*. Furthermore, in the Tamworth specimens the dissepiments are regular in size and shape and are uniformly inclined inward and downward giving a regularly inclined dissepimentarium floor. In *C. (R.) arborescens* the outer dissepiments are commonly larger and flatter and are horizontally based so that the dissepimentarium floor is horizontal peripherally and steeply inclined axially. *S. amplum* does not possess lateral dissepiments, which are variously developed in *C. (R.) arborescens*. Thus, until more material is available to allow the assessment of the range of variability of *S. amplum*, it appears unwise to consider it conspecific with *C. (R.)*



*arborescens*. However, the characters in which the two species differ do not seem to us to be of generic or subgeneric significance and *Stathmoelasma* is here considered a junior subjective synonym of *C. (Radiophyllum)*.

The following figures are considered to be of species of *C. (Radiophyllum)*:— *Phaulactis cyathophylloides* Ryder (Bulvanker, 1958, pl. 3, figs. 2a-b) from the Tiverian Ostracod Beds of the Kuz Basin; *Acanthophyllum figuratum* Spasskiy in Dubatolov and Spasskiy (1964, pl. 10, figs. 1a-b) from the middle part of the Bolchévortsk Beds, upper Eifelian of the Nakhechevan USSR; *Stenophyllum spinulosum* Soshkina (Spasskiy, 1960c, pl. 5, figs. 1-4) from the D<sub>1</sub>-D<sub>2</sub> Imachi suite of the upper Amur and eastern Transbaykal; *Zaphrentis cailliaudi* Barrois (1889, p. 47, pl. 2, fig. 2) from the Calcaire d'Erbray (Emsian), France.

The first syntype of *Disphyllum (Sinodisphyllum) variabile* Sun, the type species of the subgenus, figured by Sun (1958, pl. 4, figs. 1a-e) from the Upper Devonian of Hunan, China, shows characters in the adult stages very similar to those of *C. (Radiophyllum)*. However, the form of septal dilation in the early stages of growth is of the disphyllid type. The other syntypes figured by Sun are closer to *Mansuyphyllum annamiticum* (Mansuy) the type species of *Mansuyphyllum* Fontaine (1961).

*Distribution*:— Eastern Australia, Emsian and Lower Couvinian; France, Emsian; USSR, Lower Devonian, Eifelian.

#### Subgenus CYATHOPHYLLUM (PERIPAEDIUM) Ehrenberg, 1834

*Synonymy*:— *Keriophyllum* Wedekind, 1923, pp. 27, 34; *Ceriophyllum* Lang, Smith & Thomas, 1940 (*nomen vanum*); *Loomberaphyllum* Pedder, 1965, p. 213.

*Type Species* (chosen Lang, Smith & Thomas, 1940, p. 97):—*Cyathophyllum turbinatum* Goldfuss (1826, p. 56, pl. fig. 8c) from the Ahrdorf Beds (Eifelian) of the Hillesheim Syncline, Eifel, Germany.

*Diagnosis*:— *Cyathophyllum* with long, smooth or heavily carinate major septa extending to the axis; tabularial floors horizontal to strongly arched, composed of numerous small convex tabellae.

*Remarks*:— Birenheide (1963) has discussed the synonymy of this subgenus and its relationship to *C. (Cyathophyllum)*. He regards the failure to develop retiform septa in the peripheral parts of most corallites as a subgeneric character. However, specimens from 'Pandanus Creek', Broken River, north Queensland show septa that are strongly retiform at the periphery but otherwise resemble *C. (Peripaedium)* especially in their tabularial characters.

*Loomberaphyllum* Pedder (1965) with type species *L. pustulosum* Pedder (1965, pp. 214-5, pl. 32, figs. 8, 9; pl. 34, figs. 7, 9) from the Couvinian Loomberah Limestone of New South Wales was proposed for forms

similar to *Cyathophyllum* but with bilateral symmetry, developed by the shortening of the cardinal septum, and with the trabeculae set at a low angle to the horizontal. The latter feature is associated with the steepness of the dissepimentarial floors of the Australian form. Bilateral symmetry is visible in some of the Eifel specimens referred to *Cyathophyllum*. The Loomberah species has retiform or split septa at the periphery, like the above mentioned north Queensland specimens of *C. (Peripaedium)*. The tabularial characters of *Loomberaphyllum* are similar to those of *C. (Peripaedium)*, with which it is equated.

*Tipheophyllum* Hill, 1956a, type species *T. bartrumi* (Allan) from Reefton, New Zealand, was doubtfully included in *Cyathophyllum* by Birenheide (1963). The tabularial characters suggest a closer affinity to *C. (Peripaedium)* than to the other subgenera of *Cyathophyllum*. However, the trabeculae are relatively broad simple monacanth, like those commonly found in the disphyllids, and the thin carinate septa are more like those of the disphyllids than those of the cyathophyllids. We refer it to the Disphyllinae Hill, 1939, but do not agree with Pedder (1966) that the Disphyllinae is a subfamily of Cyathophyllidae.

In the Eifel, *C. (Peripaedium)* entered earlier in the Eifelian than *C. (Cyathophyllum)* and extended into the Givetian. In the USSR, it occurs in the Givetian and we refer the following species to it:— *Charactophyllum spongiosum* (Schluter) of Soshkina (1952, pl. 28, fig. 97) from the Givetian of the Urals; *Charactophyllum spongiosum* (Schluter) of Zheltonogova & Ivaniya (1961, pl. D54, figs. 1a-b) from the lower Givetian of the Salair; *Heliophyllum carinatum* Bulvanker (1958, pl. 50, fig. 1) from the upper Givetian Safonovo beds of the Kuz Basin (may be conspecific with *C. spongiosum* of Zheltonogova & Ivaniya cited above). *Leptoinophyllum hedstroemi* Wedekind of Zheltonogova & Ivaniya (1961, pl. D30, fig. 5) from the Eifelian of the Altai, is doubtfully referred to the subgenus. *Stenophyllum spinulosum* Soshkina (1952, p. 93, pl. 32, fig. 107) from the Eifelian of Armenia may well be referable to *C. (Peripaedium)*, but no vertical section is given; the specimens referred to this species from the Amur by Spasskiy (1960c) are closer to *C. (Radiophyllum)* in having well-arched tabularial floors, globose periaxial tabellae, and sagged axial tabellae.

Specimens from the Middle Devonian of Yunnan referred to *Keriophyllum* by Wang (1948) are not sufficiently well illustrated for reliable generic identification, and some may be solitary disphyllids. As mentioned earlier, Fontaine (1966) described a form from the Middle Devonian (upper Couvinian or lower Givetian) of Poshi, Yunnan, as *Peripaedium poshiense*, which is intermediate in form between *C. (Peripaedium)* and *Heliophyllum*. Fontaine (1961, pl. 16, figs. 1a-c; pl. 17, fig. 4) compared a specimen from the Givetian of Viet-Nam with *Cyathophyllum convolutum* Mansuy (1920, pp. 17, 18, pl. 3, figs. 1a-b) and referred the species to *Keriophyllum*; his figures of transverse sections suggest *C. (Peripaedium)*. The generic relations of *Keriophyllum conicum* Sun (1958, pl. 10, figs. 2a-d) from the Frasnian Shaitienchiao



Formation of Hunan are not interpretable on the figures available. *Cyathophyllum helianthoides* var. *spinulosum* Reed (1908, pl. 1, figs. 7, 8) and possibly *C. cylindricum* (Schulz) of Reed (1908, pl. 1, figs. 9, 10) from Padaukpin, northern Shan States, Burma, probably Couvinian, are referable to *C. (Peripaedium)*.

In Australia, *C. (Peripaedium)* is known from the Couvinian limestones of Pandanus Creek Station, north Queensland (UQF 50512), the Couvinian Loomberah Limestone of Tamworth, New South Wales [*Mictrophyllum* cf. *cresswelli* (Chapman) Hill (1942c, p. 159, pl. 3, fig. 9) = *Loomberaphyllum pustulosum* Pedder (1965, p. 214, pl. 32, figs. 8, 9; pl. 34, figs. 7, 9)], and the probably Siegenian (see above under remarks on family Cyathophyllidae) Cooper's Creek Formation at Tyers River, Gippsland, Victoria [*Acanthophyllum clermontensis* (Etheridge) Philip (1962, pp. 185-6, pl. 27, figs. 1, 2) = *Loomberaphyllum impensum* Pedder (1965, p. 215, pl. 34, fig. 10)]. The specimen described as *Cyathophyllum* sp. by Dun in Benson (1918, pp. 376-7, text-fig. 4), from the Loomberah Limestone near Tamworth, New South Wales, may well be referable to this group.

Only a few occurrences have been cited from North America. McLaren in McLaren & Norris (1964) described *C. (Peripaedium) greteneri* (pl. 6, figs. 2, 3; pl. 7, figs. 1a-b) from the Givetian Horn Plateau Formation of northwest Canada. The specimen figured by McLaren in McLaren, Norris & McGregor (1962) as *Keriophyllum* sp. F. has a tabularium with incomplete tabulae, as in *C. (Peripaedium)*, and is perhaps best retained in *C. (Peripaedium)*, though the tabulae form flat tabularial floors and become elongate in the axial region, as in *C. (Cyathophyllum)*. It is from the Givetian middle part of the Presqu'île Formation of northwest Canada. McLaren in McLaren & Norris (1964) suggested that the specimen described as '*Cyathophyllum*' *kobehense* Stumm by Lenz (1961, p. 503, pl. 1, figs. 13-16) from the Givetian Ramparts Limestone of northwest Canada may be conspecific with the Presqu'île specimen. The paratype of '*Cyathophyllum*' *kobehense* Stumm (1938, pl. 59, figs. 1a-b), from the Eifelian middle section of the Nevada Limestone, western United States, shows arched tabularial floors of numerous tabellae, but the small size and fineness of the tabellae is uncommon in *C. (Peripaedium)*, to which we doubtfully refer it.

A more natural classification than the one we have adopted herein may include the subgenus *C. (Sterictophyllum)* as diagnosed below, in *C. (Peripaedium)*. The species placed by Pedder in *Loomberaphyllum*, *Sterictophyllum*, and *Cavanophyllum* are all characterized by calical platforms which are steeply declined axially, and by domed tabularial floors, formed by numerous small globose tabellae, the domes sagging axially in some individuals. *Sterictophyllum* and its probable synonym *Cavanophyllum* differ from *C. (Peripaedium)* in the peripheral thickening of the septa to form a stereozone of variable width and persistence. For the time being, we retain *C. (Sterictophyllum)* because this stereozone is not seen in other cyathophyllids.

*Distribution*:— Europe, Eifelian and Givetian; USSR in Asia, Eifelian? and Givetian; China, Viêt-Nam and Burma, Couvinian and Givetian; Australia, Siegenian? and Couvinian; North America, Couvinian? and Givetian.

#### Subgenus CYATHOPHYLLUM (STERICTOPHYLLUM) Pedder, 1965

*Synonymy*:— *Cavanophyllum* Pedder, 1965, pp. 215-6.

*Type Species* (by original designation):— *Cyathophyllum cresswelli* Chapman (1925, pp. 111-2, pl. 13, figs. 11-14), from the Lilydale Limestone at Cave Hill, Lilydale, Victoria; Siegenian or Emsian (see above, under remarks on family Cyathophyllidae).

*Diagnosis*:— Solitary *Cyathophyllum* with septa extending to the axis and variably dilated peripherally; dissepimentaral floors steeply inclined axially; tabularial floors steeply domed or arched, but flattened axially, consisting of numerous small tabellae.

*Remarks*:— Pedder (1965) proposed *Sterictophyllum* to include three species of Lower Devonian cyathophyllids from Victoria. He distinguished this genus from *Cyathophyllum* by its solitary form and different arrangement of the trabeculae. However, Birenheide (1963) has shown that the solitary and colonial species of the Eifel are sufficiently alike in internal characters to be grouped together in one subgenus. The trabecular pattern in *Sterictophyllum* differs only in that the trabeculae are arranged at a low angle to the horizontal, and result from the high inclination of the calical floor. Considering the variation in the other subgenera of *Cyathophyllum*, these differences are not considered to warrant generic differentiation. However, it may be advisable to distinguish this group with its highly elevated tabularium and its septa dilated or modified peripherally as a subgenus of *Cyathophyllum*, namely *C. (Sterictophyllum)*.

Pedder (1965, p. 215) also proposed the genus *Cavanophyllum* for one species, *Mictrophyllum trochoides* Hill, from the Cavan Bluff Formation at Cavan, Taemas, southern New South Wales. Philip & Pedder (1967b), mainly on the presence of the conodont *Polygnathus linguiformis dehiscens* Philip & Jackson, consider the Cavan Bluff Limestone to be late Siegenian rather than early Couvinian or late Coblenzian, as suggested by Hill (1940). The holotype of this species shows a very close resemblance to *C. (Sterictophyllum) cresswelli*, except in the form of the corallum and the peripheral characters of the septa. In the outer dissepimentarium, the septa become retiform and contain numerous 'vacuoles', rather than being dilated as in *C. (S.) cresswelli*. *Cavanophyllum* is probably a synonym of *C. (Sterictophyllum)*. Pedder regarded the former as a member of the Cyathophyllidae to which *C. (Sterictophyllum)* is now referred.

Representatives of *C. (Sterictophyllum)* have not been recognised outside Australia. The four species in Australia are: *Cyathophyllum cresswelli* Chapman (1925, pp. 111-2, pl. 13, figs. 11-14) [= *Mictrophyllum cresswelli* (Chapman), Hill (1939, pp. 246-8, pl. 14,



figs. 7-11) = *Sterictophyllum cresswelli* (Chapman), Pedder (1965, p. 211-3, pl. 32, figs. 1-7; pl. 33, figs. 1-6; pl. 34, figs. 3, 4.)] from the Siegenian or Emsian Lilydale Limestone of Cave Hill, Lilydale, Victoria; *Sterictophyllum vallatum* Pedder (1965, p. 213) [= *Mictophyllum* sp. aff. *M. cresswelli* (Chapman), Philip (1962, p. 180, pl. 23, figs. 3, 4)] from the probably Siegenian Cooper's Creek Formation, Tyers River, Victoria; *Dohmophyllum pridianum* Philip (1962, pp. 187-8, pl. 28, figs. 8, 9), locality as for *C. (S.) vallatum*; *Mictophyllum trochoides* Hill (1940, pp. 265-6, pl. 11, fig. 7-10) [= *Cavanophyllum trochoides* (Hill), Pedder (1965, pp. 216-7, pl. 33, figs. 7-10; pl. 34, figs. 5, 8, 11, 12)] from the Cavan Bluff Formation, Taemas, New South Wales.

*Distribution*:— Eastern Australia, Siegenian to early Couvinian?

#### Family PHILLIPSASTRAEIDAE Roemer, 1883

From an extensive review of the family Phillipsastraeidae by one of us (J.S.J.), the forms with horseshoe dissepiments (Phacellophyllidae of some authors) and those without (Disphyllidae of many authors) are thought to form a cognate group of family status. The family can be subdivided into five sub-families, two of which are newly named, on the structure and arrangement of the trabeculae, configuration of the dissepimental floors, development of specialized dissepiments, and septal characters (carination and dilation.) The review also emphasized the family's close relationship to the Cyathophyllidae as suggested by Hill (1956b). The details of this study are in press and will appear shortly.

#### Genus PHACELLOPHYLLUM Gürich, 1909

##### *Phacellophyllum* sp. A

Pl. 2, figs. 1-3

*Material*:— Five specimens UQF53884-8, from pebbles in the conglomerate at the base of the Drummond Group, 2.75 miles west of Pyramid homestead, southwestern part of the 1:250,000 Sheet area, Ukalunda district, north Queensland.

*Description*:— The corallum appears fasciculate with curved cylindrical corallites from 4.5 to 7.5mm in diameter. Generally the corallite wall and outer row of dissepiments are abraded giving a cog-wheel appearance in transverse section. When present, the wall is very thin. There are 19 to 20 non-carinate septa of each order and the major septa extend from half to seven-eighths of the way to the axis. The minor septa are slightly less than half as long as the major. The septa of both orders are slightly fusiform in the dissepimentarium, thinning rapidly in the outer tabularium.

The sclerenchyme of adjacent septa is never in contact. Axially the major septa may be straight and attenuate, or flexuose, or bifid with their axial ends split into two small septal plates. In UQF53385 the axial ends of the major septa are considerably dilated so that adjacent septa are in contact and form an axial tubular structure 1mm in diameter. The tabularial diameter is usually approximately two-thirds of the

diameter of the corallite. The numerous large tabellae are differentiated into an axial series of flat, horizontal or slightly domed plates and a periaxial series of smaller, convex, steeply inclined plates. The dissepimentarium is biserial, consisting of a single row of small horseshoe dissepiments and an outer row of flat horizontal dissepiments. The horseshoe dissepiments number 7 per 1mm vertically, and the flat ones 5 per 1mm.

*Remarks*:— Although very variable, this form is well within the variation limits found in a new species currently being described from the Broken River Formation, Pandanus Creek Station. The 'Pandanus Creek' form is known from the Lockup Well Limestone Member, southwest of Lockup Well (10 miles west of the homestead), which is correlated with the basal part of the Chinaman Creek Limestone Member, and is considered by one of us (J.S.J.) to be Couvinian. It is also known from pebbles in lenses of calcirudite in the upper part of the Broken River Formation. The age of the lenses is thought to be upper Givetian or early Frasnian.

#### Genus PROTOMACGEEA Rozkowska, 1956

*Synonymy*:—*Protomacgea* Rozkowska, 1956, p. 280.

*Type Species* (by original designation):— *Protomacgea dobruchnensis* Rozkowska (1956, pp. 281-287, figs. 2-8), from the middle Couvinian beds of Grzegorzowice and Wydryszów, Poland.

*Diagnosis*:— Small simple corallites, of trochoid, ceratoid, or cylindrical form without offsets and entirely covered by epitheca; lumen almost entirely filled with dilated septa and sclerenchyme; septa pinnately arranged with the cardinal septum greatly reduced and a fossula; counter septum elongate and expanded; trabeculae compound, arranged in symmetrical fans in the inner dissepimentarium; tabulae rare, complete or incomplete, horizontal or concave; outer dissepiments few, mainly as small horizontal plates at the periphery.

##### *Protomacgea* sp. A

Pl. 5, figs. 1, 2

One specimen, UQF53396, from a pebble in the conglomerate at the base of the Drummond Group, 2.75 miles west of Pyramid homestead, southwestern part of the Bowen 1:250,000 Sheet area, north Queensland is known. It has a transverse section identical with sections through the early growth stages of a new species of *Protomacgea* currently being described from the Broken River Embayment northwest of Charters Towers, north Queensland. This new form is restricted to several beds immediately above the large reefal complex at the base of the Chinaman Creek Limestone Member of the Broken River Formation in the 'Pandanus Creek' area. The age of the lower part of this unit is thought to be lower Couvinian (J.S.J.).

The only other occurrence of *Protomacgea* in eastern Australia is recorded by Dr. A. J. T. Wright, in an unpublished thesis, from the Mt. Frome Limestone in the Mudgee district, New South Wales. He considers the species to be of early Givetian age. Outside



Australia, *Protomacgeea* is known only from the type species which Rozkowska (1956) described from the middle Couvinian, beds No. 2 and No. 3 of Grzegorzowice and bed No. 3 of Wydryszów, Holy Cross Mountains, Poland.

#### Genus GURIEVSKIELLA Zheltonogova, 1961

*Type Species* (by original designation):—*Gurievskiella cylindrica* Zheltonogova in Zheltonogova & Ivaniya (1961, p. 404, pl. D 53, fig. 3), from the Malobachat beds, Salair region, central Asia; Lower Devonian. Rzhonsnitskaya (1962; 1964) referred the Malobachat beds to the Zone of *Karpinskia conjugula* and *Latono-toechia latona*, which she correlated with the upper Praguian (i.e. the lower Emsian).

*Diagnosis*:—Solitary ceratoid to cylindrical Rugosa, but may give off several offsets; calice in the shape of a goblet with flat or slightly raised floor, steep walls, and rounded rim. Septa radially or bilaterally arranged, thickened in the inner dissepimentarium so as to be spindle-shaped in transverse section, occasionally weakly carinate; axial ends of major septa carinate, slightly dilated, or fused laterally. Tabularial floor usually domed, with or without an impersistent periaxial trough; tabellae numerous, convex to flat, often elongate at the axis, usually closely spaced vertically. Dissepimentarium floor everted, formed by numerous globose dissepiments; those of the median parts of the dissepimentarium are almost horizontally based and are commonly large but those of the outer and inner series are small and strongly declined axially and peripherally. Trabeculae as monacanthi in which the fibres diverge from the trabecular axis at a low angle; monacanthi arranged in broad symmetrical fans in the median plane of the septum.

*Remarks*:—*Gurievskiella* is tentatively used to include the solitary phillipsastraeids with internal structure (fusiform long septa, strongly everted dissepimentarium floors, and usually, elevated tabularial floors) similar to that of the phaceloid *Paradisphyllum* Strusz, 1965. It is distinguished from *Temnophyllum* and *Mansuiphyllum*, i.e. solitary forms with internal characters similar to those of *Disphyllum*, essentially by its strongly everted dissepimentarium.

In Australia, the genus has been recognized in three of the eastern states. In north Queensland it occurs in the limestones on Pandanus Creek station which are at present thought to be Emsian (J.S.J. unpubl.), and near Ukalunda; in New South Wales it occurs in the Siegenian? to Emsian [see above, under remarks on *C. (Radiophyllum)*] Garra beds of central New South Wales as *Mansuiphyllum bellense* Strusz (1965, pp. 526-7, pl. 72, figs. 1-3), and possibly some of the other forms referred to *Mansuiphyllum* by Strusz; in Victoria it is represented in an undescribed fauna from the Buchan Caves Limestone at Bonanza Gully, Bindi district, east Gippsland, whose brachiopods Talent (*pers. comm.*) regards as early Couvinian, and by *Tipheophyllum* sp. Philip (1962, p. 183, pl. 25, figs. 5, 6) from the probably Siegenian Cooper's Creek Formation, Tyers area.

*Charactophyllum antiquum* Soshkina (1949, p. 91, pl. 32, figs. 4, 5, text-figs. 18, 19; 1952, pl. 25, fig. 96) from the Calceola Beds (upper Eifelian, see Spasskiy (1960b, p. 88)) of the Urals is probably congeneric with *G. cylindrica*, as is *Tortophyllum eifelensis* Vaganova in Khodalevich *et al.* (1959, pp. 83-4, pl. 38, fig. 1) from the Eifelian of the eastern slopes of the Urals.

*Temnophyllum poshiense* Wang (1948, pl. 2, figs. 14-18), Middle Devonian, Yunnan [upper Couvinian or lower Givetian — Fontaine (1966)], has its trabeculae arranged in asymmetrical fans and its dissepimentarium floors arched; it is probably referable to *Gurievskiella*. Wang (1948, p. 14) described the septal structure of *T. waltheri* Yoh as consisting of trabeculae arranged in successive fan systems that are erect in position; from this description his material could be interpreted as including *Gurievskiella*, but his figures are too poor for generic identification. His type specimen is, however, a *Temnophyllum*. On the other hand, *Campophyllum cylindricum* Yoh (1937, p. 59-60, pl. 7, fig. 4) from the Middle Devonian of Kwangsi may be referable to *Gurievskiella* in that it shows strong fanning of the trabeculae. However, it is more cylindrical and slender than the other forms of *Gurievskiella*. It occurs with *Stringocephalus burtini*.

The specimen figured by Reed (1908, pl. 1, figs. 11, 11a; pl. 2, figs. 1, 1a) as *Cyathophyllum birmanicum* from the possibly Eifelian fauna of Padaukpin in the northern Shan States of Burma, shows trabecular fans in the outer dissepimentarium and may be referable to this genus.

*Distribution*:—Australia, Lower Devonian-Couvinian; Urals and central Asia, Emsian-Couvinian; China, possibly Couvinian and Givetian; and Burma, Couvinian.

#### *Gurievskiella talenti* sp. nov. Pl. 3, figs. 1, 3-8

*Holotype*:—UQF52775, from B84F, Ukalunda Beds 2 miles slightly north of west of Hidden Valley homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 Sheet area, north Queensland; probably Couvinian.

*Diagnosis*:—Moderately large solitary Rugosa with long, straight, thin to fusiform septa slightly withdrawn from the axis, arranged bilaterally about a cardinal fossula or the conjoined counter-cardinal septum; tabularium variable, domed, consisting either entirely of small globose tabellae, or of two series — a periaxial series of flat horizontal or concave tabellae, and an axial series of larger convex tabellae; dissepimentarium greatly everted, consisting of small numerous, globose dissepiments except for sparse, large, almost horizontally based ones in the medial parts.

*Description*:—All the specimens are abraded fragments of what appear to be single, slightly curved, ceratoid to subcylindrical corallites. Their diameters range from 20 to 40mm and the largest specimen measures 45mm in height. The external features are not known. Parts of the wall are preserved only in three specimens and in them it varies in thickness from 0.04 to 0.06mm.



There are 27 x 2 to 38 x 2 long straight septa, slightly to moderately dilated in the medial parts of the dissepimentarium. Occasionally, the major septa are slightly thicker in the tabularium, while others are thin or even flexuose. The septa are bilaterally arranged in two orders. In the holotype, an open fossula is developed on the convex side of the corallite and is slightly expanded axially. The cardinal septum is the shortest major septum and is only slightly longer than the minor septa. The counter is the longest septum and extends to the axis. All the corallites from B84F show this bilateral symmetry about a fossula. Specimens from B76F do not show distinct fossulae, but are bilaterally symmetrical about the conjoined counter-cardinal septa. In all forms, the other protosepta and metasepta are slightly withdrawn giving a narrow axial space bisected by the counter septum, or by the conjoined counter and cardinal septa. The minor septa are half the length of the major and occasionally are discontinuous in the inner dissepimentarium. A single specimen (UQF52778) appears to show carinae and these are very short and may not be continuous vertically. In tangential sections, the septa of some corallites appear to carry short, thin, spinose projections (vepreculae).

The tabularial diameter varies from a third to a half that of the corallite. The floors are well elevated and in the holotype are differentiated into a periaxial trough and an axial platform. The trough is formed by flat or convex plates, and the platform of larger convex tabellae. In specimens from B84, the trough is pronounced and the two series of tabellae are sharply delineated. In these, the trough is deepest beneath the fossula. A similar type of tabularium is found in one specimen (UQF40318) from B76, but in the others from this locality the trough becomes narrow and less distinct and the tabellae are not differentiated into two series.

The dissepimentarial floor is extensively everted. The dissepiments are generally small, numerous, globose, and variously arranged. Those of the medial parts of the dissepimentarium are very globose, almost horizontally based, and in places much larger than the others. However, in some corallites the development of these larger plates is restricted to various levels in the vertical section. Axially and peripherally, the dissepiments become progressively more steeply declined away from the central series, but those of the peripheral row flatten at the corallite wall.

The septa are monacanthine with the fibres of each monacanth only slightly divergent from its axis. Hence, in longitudinal section, the trabeculae are not well delineated and the septa appear fibrous. The monacanths are arranged in a symmetrical fan, the axis of which corresponds to that of the medial series of dissepiments.

*Remarks:*— The specimens from B76 differ from those of the type locality in that instead of possessing a fossula, their counter and cardinal septa are joined, their septa are slightly longer, and except for one specimen, they do not have such a pronounced depression surrounding the axial series of tabellae.

Although the material is insufficient to be certain, it is probable that the forms from both localities are conspecific and that one group is a mere variant of the other. Similar variation is seen in a new species referable to this genus from the Lower Devonian strata on Pandanus Creek station, north Queensland. Its counter and cardinal septa are always joined, but in some, the dissepimentarium narrows and a slight depression of the tabularial floors occurs about the cardinal septum.

*G. talenti* is not easily assigned to a particular genus, or to a particular family. It possesses characters common to both the Phillipsastraeidae and the Cyathophyllidae. In its septal dilation, microstructure, and everted dissepimentarium, it resembles a number of Australian species that form a closely related group: '*Phillipsastraea*' *aperta* Hill, '*Hexagonaria*' *approximans* (Chapman), *Paradisphyllum harundinetum* Strusz, *P. ops* (Philip), and some if not all of the solitary forms that Strusz (1965) included in *Mansuiphyllum*. As discussed above, we tentatively include this group in the Phillipsastraeidae, and are including the solitary forms in *Gurievskiella*. The Ukalunda corallites are much larger than those of the other species listed above and, with its long straight septa and typically wide elevated tabularium composed of many tabellae, the Queensland species might well be a cyathophyllid close to *C. (Radiophyllum)*. The tabularium seems more variable than in most species of *Cyathophyllum* and the marked bilateral symmetry, together with the development of a fossula, is more reminiscent of *Heliophyllum*. However, the Cyathophyllidae do not show such steeply everted dissepimentaria, or such globose dissepiments as the Queensland form; these two characters are typically phillipsastraeid.

The Ukalunda species is distinguished from the other Australian forms by its size, wide tabularium, and the variation in size of the dissepiments forming the central series of the dissepimentarium. It does not closely resemble any of the overseas species referable to this genus.

*Material:*— There are 4 specimens from the type locality B84F, and 12 from B76F (see text-fig. 1); probably Couvinian.

#### Genus CERATOPHYLLUM Gürich, 1896

*Type Species* (by monotypy):— *Ceratophyllum typus* Gürich (1896, p. 181), Stinkkalken, Szydlowek, Poland; Middle Devonian (possibly lower Givetian). For redescription of type species see Fedorowski (1967).

*Diagnosis:*— Corallites solitary or weakly colonial with a few small offsets; major and minor septa variably carinate; dissepimentarial floors horizontal peripherally, but inclined near the inner margin, or broadly everted; dissepiments small and globose, without horseshoe dissepiments; trabeculae composite, arranged in broad asymmetrical fans or half-fans; symmetry bilateral in early ontogeny with prominent counter septum, radial in ephebic stage (after Fedorowski, 1967).



*Remarks:*— Following Fedorowski's (1967) interpretation of the solitary forms, we believe *Ceratophyllum* to be close to *Macgeea* Webster in having trabeculae of the composite type, like those found in *Phillipsastrea*, and in having these trabeculae arranged in fans. It differs from *Macgeea*, however, in the broadness of the fans, and in the lack of horseshoe dissepiments. *Ceratophyllum* is thus distinguishable from the solitary disphyllids, for the latter have simple monacanthine septa, and their dissepimental floors slope evenly and steeply downward to the axis.

*Distribution:*— Poland, Middle Devonian (possibly lower Givetian); Urals, upper Eifelian *Calceola* Beds (as *Cyathophyllum ceratites* Goldfuss of Bulvanker (1934, pl. 4, figs. 4-6)).

*Ceratophyllum* sp. A.  
Pl. 2, figs. 4-7

*Material:*— Three specimens, UQF52788-90 from the Ukalunda Beds at B76F, (see text-fig. 1); probably Couvinian.

*Description:*— All the specimens are fragmentary and appear to be of small, conical to subcylindrical solitary corallites up to 20mm in diameter. At a diameter of 15mm there are 29 septa of each order with the minor septa varying in length from half to three-quarters of that of the major septa. The major septa extend from two-thirds to three-quarters of the way to the axis. The septa of both orders are thin and somewhat flexuose in the tabularium, and slightly dilated at the boundary between dissepimentarium and tabularium; they are only rarely and lightly carinate. In the only complete transverse section obtained, the septa are bilaterally arranged about a shortened cardinal, and lengthened counter septum; the short septum bisects a wide, open fossula.

In longitudinal section the wide tabularium is sharply delimited from the narrow dissepimentarium. The tabularial floors are concave distally, and are composed of large, horizontal, complete, axial tabellae surrounded by a small, globose, steeply inclined, periaxial series. The dissepiments are small, globose; in longitudinal section wider than they are high, and commonly horizontally based. The resultant dissepimental floors are either slightly everted, or horizontal except at their inner edge where they slope downward axially.

The trabeculae are wide, slightly fanned over the dissepimental floors, and in longitudinal section show traces of secondary trabeculae that diverge laterally from the central axis of the primary trabecula, like those in *Phillipsastrea*.

*Remarks:*— The north Queensland form is referred to *Ceratophyllum* owing to its solitary form, dissepimental characters, and the nature of its trabeculae. It differs from *C. typus* in the form of its corallum, which is less conical and smaller, and in its thinner and straighter septa.

Another specimen, UQF52793, from B84F (see text-fig. 1) is probably referable to this species. One transverse section is available, but it shows the interseptal dissepiments at the periphery to be elongated radially, and very like those in the specimens from B76F.

Genus TEMNOPHYLLUM Walther, 1928

*Temnophyllum?* sp.

Pl. 2, figs. 8-9

*Material:*— Four incomplete specimens UQF 52784-7 from the Ukalunda Beds at B76F (see text-fig. 1); probably Couvinian.

*Description:*— All specimens are fragments of slender subcylindrical corallites up to 12mm in diameter. No information as to the external characters is available. The septa are radially arranged with 26 to 28 in each order. The major septa extend almost to the axis, and are usually considerably dilated in the tabularium, and commonly fused at their axial ends. The minor septa are thin and less than half as long as the major septa. Occasionally, the septa carry short stout zigzag carinae in both the tabularium and the dissepimentarium. In one specimen (UQF52785), the major septa become spinose axially, with the spines representing the distal projections of the wide, simple monacanthine trabeculae.

The tabularium is relatively wide, with horizontal or slightly sagging tabularial floors formed by large flat tabulae supplemented sporadically, at the periphery, by globose periaxial tabellae. The dissepimentarium is narrow and consists of one to five rows of small globose dissepiments declined steeply towards the axis.

*Remarks:*— Previously, solitary forms with internal characters similar to those of *Disphyllum* have been placed in a variety of genera. Their affinities will be discussed in a future work by us. Although the type species of *Temnophyllum* (*T. latum* Walther) exhibits a prominent and wide peripheral stereozone, we consider it probable that many of the solitary forms lacking such a stereozone are still congeneric with *T. latum*.

The Queensland form is distinguished from all previously described solitary disphyllids by its narrow dissepimentarium and the dilation of the septa in its tabularium.

|          |                               |
|----------|-------------------------------|
| Suborder | COLUMNARIINNA Rominger, 1876  |
| Family   | PTENOPHYLLIDAE Wedekind, 1923 |
| Genus    | ACANTHOPHYLLUM Dybowski, 1873 |

*Acanthophyllum* sp. indet.  
Pl. 3, fig. 2

One longitudinal section, UQF53397, from a pebble in the conglomerate at the base of the Drummond Group 2.75 miles west of Pyramid homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 Sheet area, north Queensland, is referable to *Acanthophyllum*, but specific identification is not possible.

|          |                                                         |
|----------|---------------------------------------------------------|
| Suborder | CYSTIPHYLLINA Nicholson in Nicholson and Lydekker, 1859 |
| Family   | TRYPLASMATIDAE Etheridge, 1907                          |
| Genus    | TRYPLASMA Lonsdale, 1845                                |

*Tryplasma* sp.  
Pl. 4, fig. 9

*Material:*— One specimen, UQF53395, from a pebble in the conglomerate at the base of the Drummond Group, 2.75 miles west of Pyramid homestead,



Ukalunda district, southwestern corner of the Bowen 1:250,000 Sheet area, north Queensland.

**Description:**— This form is represented by a single ceratoid to cylindrical corallite which has a maximum diameter of 25mm and a height of 50mm. Its external and calical features are not known. There are 46 x 2 septa, at a diameter of 20mm, confined to a narrow peripheral zone less than 2.5mm in width. The minor septa are a little shorter and thinner than the major. The tabulae are distant, complete, horizontal or slightly domed, occasionally thickened, and steeply upturned at their peripheral edges.

The microstructure of the skeletal elements is well shown in the specimen. The septa consist of a single series of distant rhabdacanths embedded in lamellar schlerenchyme, except near their axial ends where the trabeculae project as small, short spines. The lamellar tissue is continuous from one septum to another. The tabulae may be thickened and then consist of numerous thin lamellae arranged in echelon series as described by Hill (1936, p. 205). Small holacanths perpendicular to the surface of the tabulae disrupt the lamellae. They are much thinner than the rhabdacanths of the septa.

**Remarks:**— This form somewhat resembles *T. wellingtonense* Etheridge, 1895, from the Devonian of New South Wales, from which it is distinguished by the shortness of both its septa and the spines at their axial edges. In its shortness of septa, corallite diameter, and septal number, it resembles a transverse section of a specimen from Loomberah, Tamworth district, New South Wales, though the latter has slightly longer septal spines and the lamellar tissue is not as well developed around the axial ends of the septa. The coral fauna from Loomberah is probably Couvinian in age.

Family            CYSTIPHYLLIDAE Edwards and Haime, 1850

Subfamily       PLASMOPHYLLINAE Dybowski, 1873

(ex Plasmophyllidae Dybowski, 1873, *nom. transl.* Zittel, 1876)

**Diagnosis:**— Predominantly solitary Rugosa, the calices flat or funnel-shaped with sloping, flat, or everted calicular platforms. Septa normally incomplete, of short, fine, isolated, corn-like trabeculae developed sporadically on the dissepiments and tabellae, or of coarse trabeculae that may be united in radial longitudinal segments of septa; such septal formation is commonly periodic, occurring on certain calicular floors, or parts of floors, which may also be distinguished by skeletal thickening affecting septa, dissepiments, and tabulae, giving stereocones; in some, major septa may be complete, but fading peripherally, or peripherally replaced by isolated cross-bar carinae. Cardinal fossula may be present. Dissepimentarium commonly wide and difficult to distinguish from tabularium either by change of slope, or size of the curved plates.

**Distribution:**— Cosmopolitan, Lower and Middle Devonian.

**Remarks:**— The revision by Birenheide (1964) of the cystimorphs of the Eifel represents a major advance in our understanding of the cystiphyllids. He concluded that in the Devonian of Germany only one genus of the

family was present, and that it showed extreme variation in its septal characters within species, and that it is divisible into two subgenera on these septal characters. Thus, *Plasmophyllum* (*Plasmophyllum*) includes those relatively aseptate species commonly, until now, referred to *Cystiphyllum*; and *P. (Mesophyllum)* includes those commonly referred to either *Mesophyllum* or *Digonophyllum*, that is, those in which the major septa consist of more or less continuous radial longitudinal plates.

Before a stable solution could be reached, certain problems of nomenclature had to be solved. The first difficulty, that of the type species of *Plasmophyllum*, Birenheide overcame by accepting Schlüter's (1885) usage of *P. goldfussi* (Edwards and Haime, 1851 non Castelnau, 1843) as the first name given to a species of *Plasmophyllum* Dybowski (1873). Dybowski gave only generic name and diagnosis, without species name, illustration, or age. Birenheide rejected Schlüter's later (1889) naming of the Silurian *Cystiphyllum breviamellatum* M'Coy as type species.

A second difficulty, that of inability to locate at present in the Paris Museum of Natural History, the specimen figured by Edwards and Haime as *Cyathophyllum goldfussi*, is avoided *pro tempore* if we accept Birenheide's conclusion that the first valid name to be applied to the species to which Edwards and Haime's specimen belonged was *Cyathophyllum limbatum* Quenstedt, 1879. We have no illustrations of the internal structure of Edwards and Haime's specimen, but certainly, the calical view of Birenheide's lectotype of Quenstedt's species is similar to that which we would expect from Edwards and Haime's calical view. Unfortunately, Birenheide did not give photographs of thin, transverse and longitudinal sections of his lectotype, and though he did figure a polished transverse surface, we cannot satisfy ourselves completely that the non-type specimens he referred to *limbatum* are really conspecific with his lectotype.

#### Genus PLASMOPHYLLUM Dybowski, 1873

**Synonym:**— See below for subgenus *P. (Plasmophyllum)* and see Birenheide (1964) for *P. (Mesophyllum)*.

**Type Species** [by subsequent designation of Schlüter (1885)]:— *Cyathophyllum goldfussi* Edwards & Haime, 1851 (non Castelnau, 1843) = *Cyathophyllum limbatum* Quenstedt, 1879 = *Plasmophyllum eifelense* Stumm, 1949, *nomen novum* for *Cyathophyllum goldfussi* Edwards & Haime, non Castelnau.

**Diagnosis:**— Predominantly solitary Rugosa, the calices flat or funnel-shaped with sloping, flat or everted calicular platforms. Septa normally incomplete, of short, fine, isolated corn-like trabeculae developed sporadically on the dissepiments or tabellae, or of coarser trabeculae that may be united in radial, longitudinal segments of septa; such septal formation is commonly periodic, occurring on certain calicular floors, or parts of floors, which may also be distinguished by skeletal thickening affecting septa, dissepiments and tabellae, giving stereocones. Major septa in some may



be complete radial longitudinal plates but fading peripherally or replaced peripherally by isolated cross-bar carinae. One of the two counter minor septa may be as long as, or longer than, the counter and counter lateral septa. Cardinal fossula, when distinguishable, of key-hole section. Dissepimentarium commonly wide, and dissepiments difficult to distinguish from the tabellae either by change of slope or size.

*Distribution*:— Cosmopolitan, Lower and Middle Devonian.

*Remarks*:— The variable species of this extremely variable genus may be grouped into two subgenera, mainly based on the degree of completeness of the septa. Both subgenera are present in eastern Australia, but only one, *P. (Plasmophyllum)*, is found near Ukalunda.

Subgenus PLASMOPHYLLUM (PLASMOPHYLLUM)  
Dybowski, 1873.

*Synonymy*:—? *Coleophyllum* Hall, 1883; *Bucanophyllum* Ulrich, 1886; *Stereophyllum* Schlüter, 1889, non Grabau, 1917, nec Soshkina, 1937; *Cystiphyllodes* Chapman, 1893; ?*Tillophyllum* Wedekind, 1923 (*nomen nudum*); ?*Sphaerophyllum* Wedekind, 1923 (*nomen nudum*); *Lekanophyllum* Wedekind, 1923 (*nomen nudum*); *Legnophyllum* Wedekind, 1924; *Zonophyllum* (*Zonophyllum*) Wedekind, 1924; *Zonophyllum* (*Legnophyllum*) Wedekind, 1924; *Pseudozonophyllum* Wedekind, 1924; *Lythophyllum* (*Lythophyllum*) Wedekind, 1925; *Lythophyllum* (*Paralythophyllum*) Wedekind, 1925; *Nardophyllum* Wedekind, 1925; *Plagiophyllum* Wedekind & Vollbrecht 1931; *Skoliophyllum* Wedekind, 1937; *Atelophyllum* (*Cystiphyllodes*) Yoh, 1937 (non *Cystiphyllodes* Chapman, 1893; non *Atelophyllum* Wedekind, 1925); *Pseudomicroplasma* Soshkina, 1949; *Wedekindophyllum* Stumm, 1949; *Cystiphyllodes* (*Cystiplasma*) Taylor, 1951; *Comanaphyllum* H. Flügel in Flügel & Flügel (1961); *Cladionophyllum* Stumm, 1961.

*Type Species*:— As for genus.

*Diagnosis*:— *Plasmophyllum* with septa of both orders lacking, or rudimentary, and consisting either of short, fine, isolated, corn-like trabeculae developed sporadically on the dissepiments and tabellae, or exceptionally, of trabeculae cohering to form pieces of septa; formation of such septal elements is commonly periodic, occurring on certain calicular floors, or parts of floors, which may also be distinguished by skeletal thickening affecting the dissepiments and tabellae, so that stereocones are formed; cross-bar carinae very rare; cardinal fossula visible in calice.

*Distribution*:— Cosmopolitan, Lower and Middle Devonian.

*Plasmophyllum* (*Plasmophyllum*) *magnivesiculosum*  
sp. nov.  
Pl. 4, figs. 1-6

*Holotype*:— UQF50902 from B84F, Ukalunda Beds, 2 miles slightly north of west of Hidden Valley homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 Sheet area, north Queensland; probably Couvinian.

*Diagnosis*:— Moderately large, solitary *Plasmophyllum* with septa represented only by rare grain-like trabeculae in very thin, rare stereocones, and with very large dissepiments and tabellae.

*Description*:— The corallum is solitary and moderately large, with one or two rather weak rejuvenescences. The average adult diameter for 16 specimens is 32mm, the range being 14 to 47mm. It is curving, and conical to subconical at first, suberect and subcylindrical later. Epithecal characters have not been observed. The calicular floor is shallow, saucer-like and, in the few specimens retaining a calice, without trabecular granules or other septal traces on the large domed surfaces of the dissepiments or tabellae.

Septa are represented only by rare, isolated, granule-like trabeculae based on the dissepiments and tabellae; stereocones are absent, or very thin and few. One specimen only could be sectioned right to the apex of the conical early stages, and it showed no skeletal thickening. Other specimens at diameters of 15mm and more showed no skeletal thickening.

The horizontal skeletal elements are mostly very large; only a few scattered small plates are present, and then mainly in a wide peripheral zone. The dissepimentarial and tabularial zones merge, and no sharp distinction can be drawn between dissepiments and tabellae either in size or shape. Both dissepiments and tabellae are large plates domed in their upper parts, so that circular sections are obtained in transverse section of the corallum, and elongated and sloping steeply downwards towards the axis in their lower parts (pl. 4, figs. 3, 6). The plates in the sub-central axial region of the corallite are elongated domes. The dissepiments and tabellae increase somewhat in size from the apical region upwards, but even in the young stages, they are relatively large. In parts of some transverse sections of corallites, the circular sections of the dissepiments are arranged in radial series. There is no skeletal thickening of the epitheca.

*Remarks*:— One specimen only UQF52700 (Pl. 4, figs. 1a, 1b), a short curved and rather stout conical individual, does show thick trabeculate radial septal segments in an irregular peripheral zone at a diameter of 20mm, and stereocones. The size of the dissepiments and tabellae is, however, similar to that in the other 16 specimens; it seems possible that it is merely a variant of the normally thin-plated species described above, but in view of the small size of the sample, there can be no certainty and we place it only doubtfully in this species.

Of the species from the Eifel described by Birenheide (1964), our species resembles *P. (P.) macrocystis* (Schlüter) in the size of the tabellae, but lacks the characteristic eccentricity of the axis, and the rare stereocones of the German corals; additionally the Australian species has larger plates. It differs from *P. (P.) secundum* (Goldfuss) in the great size of its dissepiments and tabellae, but possibly could be a local subspecies of that widely distributed species. The numerous circular sections of its dissepiments and tabellae recall those of the adult, unthickened stages of some *P. (P.) lamellosum* (Goldfuss).



**Material:**— Eight specimens (including the holotype) from B84F, thirteen specimens from B76F, and one specimen doubtfully referred to the species from B76, Ukalunda Beds (see text-fig. 1), probably Couvinian; and one specimen, UQF52726, from the lower part of the Chinaman Creek Limestone Member, Broken River Formation, "Pandanus Creek", Broken River Embayment, thought to be Couvinian by one of us (J.S.J.) on its coral fauna.

**Comparison with foreign material:**— The holotype of *Plasmophyllum* (*Plasmophyllum*) *salairicum* (Peetz), as figured by Bulvankar (1958, pl. 13, figs. 1a-g) has an openness of texture and thinness of plates very like that of our Ukalunda species, but it is a slender form with maximum diameter of 16mm between rejuvenescences. It is from the upper Krekov horizon of the Salair, which according to Rzhonsnitskaya (1962) is probably to be correlated with the Siegenian of western Europe.

Kravtsov (1963) has figured a very similar species with thin, large plates from the third "packet" of the Lower Devonian Tarei Suite of the central Taimyr (correlated with the Krekov horizon) under the names *Pseudomicroplasma salairica* (Peetz), *P. magna* (Chernyshev), and *P. momentaria* Kravtsov. Their range of variation and their early stages are all unknown, so that complete comparison with the Ukalunda species cannot be made. None of the illustrations of Australian or American plasmophyllids can be compared closely with our species.

#### Family GONIOPHYLLIDAE Dybowski, 1873

The septa in this family are rarely complete radial longitudinal plates, but are, as in other members of the suborder Cystiphyllina, normally represented by discrete trabeculae, or by trabeculate segments. They may be so thickened as to be laterally contiguous, or they may be almost completely absent. No studies of septal insertion have been made, and no cardinal or alar fossulae such as denote the rugosan positions of metaseptal insertion in the Streptelasmatina have been identified. It is presumed that minor septa are developed, but they are seldom indentifiable with certainty; consequently the usual means of distinguishing between dissepimentarium and tabularium is denied us. In all these characters the family resembles the Cystiphyllidae from which it differs in the external form of the corallum which is either semicircular, semiellipsoid, or quadrate in section. Colonies are known only in one genus — *Rhizophyllum*.

#### Genus CALCEOALA Lamarck, 1799

*Calceola*, with its semiellipsoid transverse section and operculum is characterized by regular shape, by absence of rootlets, and by dense packing of elements which normally precludes development of tabellae or dissepiments. However, in some specimens of the type species from the Eifel, *C. sandalina* Linnaeus, one or two sub-conical spaces may be left in the apical part of the corallum, each space sealed at the top by a flat bottomed, or very slightly arched, thick development of growth-layered, but obscurely trabeculate, scleren-

chyme. A median longitudinal section showing this condition in a topotype is seen in pl. 5, figs. 3, 4. Such specimens are not present in the collections from Ukalunda.

Many records of *Calceola* are unsupported by descriptions or illustrations of internal structure, so that its value as a horizon-marker has been decreased. Lower Devonian records should be further investigated to see whether they refer to *Calceola* and not to *Rhizophyllum* which extends into the Lower Devonian from the Upper Silurian, and which may indeed extend into the Middle Devonian, though well supported cases are not known. Lower Devonian records of *Calceola* unsupported by illustrations of thin sections are:— Yoh (1956, p. 476) from the Emsian Kanchik Formation of Szechuan; Prantl (1937, p. 109) from the upper Emsian Zlichov Beds near Hlubocepy in Czechoslovakia; Le Maitre (1934, p. 34) from the Calcaire de Chaudefonds at the Valet Quarry, bed A, now considered upper Emsian because of its condont (Lys & Mauvier, 1965) and trilobite (Pillet, 1965) faunas; and Erben (1962), with *Acrospirifer paradoxus* in the Emsian Calcaire d'Erbray. From the Queensland Lower Devonian, Siegenian? or Emsian, Mt. Etna Limestone, true *Calceola* has been figured in longitudinal section (Hill, 1942b); it is accompanied there by *Rhizophyllum* sp. cf. *enorme* Etheridge. *R. enorme* is characteristic of the Australian Lower Devonian.

The known range of the genus is upper Emsian to Givetian; if the Australian occurrences prove to be older than upper Emsian, the range must be extended accordingly.

A species difficult to place morphologically is the Russian species that Soshkina (1949, 1952) referred to *Calceola sandalina* var. *acuminata* Mansuy, 1908. *C. sandalina acuminata* is known from the type locality only as moulds. Fontaine (1961) considered that Soshkina's identification of her Russian specimens, from the southern Urals (River Inzer), with the variety from Viêt-Nam was erroneous; Soshkina referred her specimens to the Givetian, but from Tyazheva in Olli (1961) it seems that they are probably upper Eifelian. Soshkina synonymized the species *C. macrovesiculosa* Markov (1926), from the lower Givetian [?] of the Urals, and *C. olegi* Chernyshev (1930), from the Eifelian of the Salair, with her interpretation of "acuminata".

Soshkina's (1949, 1952) figures of "acuminata" show a slender calceoloid corallum in which there is a fairly wide peripheral stereozone with the same fine structure as in *Calceola*, and an axial space crossed by a few thick tabellar floors. On these floors, the growth-laminated tissue is thinner than that in similar developments in *C. sandalina*; additionally there are a few coarse tabellae developed in the space between the floors, and on the calical slopes small thickened and highly inclined dissepiment-like plates are found. In these respects, *C. sandalina* is dissimilar. Whether this species is better placed in *Calceola* or in *Rhizophyllum* is a matter for argument. Herein, it is retained tentatively in *Calceola* owing to the simplicity of its tabellae, and the closer resemblance of its dense sclerenchyme to that of *Calceola* than to that of



*Rhizophyllum*. Also, it has the regular form of *Calceola*, and apparently lacks the rootlets commonly found in *Rhizophyllum*.

A species with some resemblance to *C. sandalina* "acuminata" of Soshkina (1949, 1952) occurs in the Lower Devonian basal beds of the Broken River Formation of north Queensland, and is described herein as *Rhizophyllum* sp. cf. *R. calceoloides* Talent.

Studies of *Calceola* by Richter (1916, 1928, 1929) and Lotze (1928) suggested that the apical angle had a taxonomic and stratigraphic value, and *C. sandalina* was subdivided into mutations (later subspecies or varieties) accordingly. However, as Bulvanker (1958) has stated, Richter's scheme appears to break down in areas outside central Europe.

*Calceola sandalina* (Linnaeus), 1771

Pl. 5, figs. 3-11

At Ukalunda, two forms of *Calceola* occur together — a broad form with apical angle ranging from 85° to 90°, and a smaller, more acute, form with apical angle ranging from 42° to 56°. These two forms are comparable in shape and apical angle with the two forms of *C. sandalina* described by Hill (1942a) from the Givetian Burdekin Limestone of Burdekin Downs and Dotswood, west of Townsville, north Queensland. Though they are smaller than the average forms from the Burdekin Limestone they fall within the ranges in size noted by Hill. No intermediates between the two forms have been recognized in either area. As the two forms occur together, we take them to be varieties rather than subspecies.

**Description:**— Two of the specimens from the Ukalunda Beds are narrow, calceoloid corallites and are turbinate in cardinal view with apical angles of 85° and 90°, respectively. They attained a height of 15mm and 11mm, measured from the apex to the centre of the calical rim on the flattened side, and maximum breadths of 19.5mm and 15mm, respectively. They are slightly curved in the plane normal to the flattened counter side, and are concave to the cardinal side. The operculum is strongly tilted away from the direction of growth so that the curved surface is much shorter than the flattened side. The external surfaces are weathered and show only coarse growth annulations. The calyx is moderately deep, with the deepest part near the margin at the centre of the curved surface.

In transverse section, the lumen is completely filled with sclerenchyme with the growth lines poorly delineated. On the flattened side, 12 septa can be distinguished on each side of the large, central, fusiform, counter septum. The septa are slightly expanded and at one third of the way to the deep central pit are deflected towards the counter septum. No septa can be recognized on the curved side. No horizontal plates can be distinguished in the dense sclerenchyme. The two specimens (UQF53088, 53093) from B76F have an apical angle which falls at the higher end of the range in size admitted by Richter (1928) for his subspecies *sandalina*. They are considerably narrower between the flat and curved faces than the forms from

the Givetian Burdekin Limestone referred by Hill (1942a) to Richter's subspecies *sandalina*.

Sixteen of the specimens from the Ukalunda Beds are small, narrow corallites trochoid in cardinal view, with the apical angle varying from 42° to 56° (most individuals are between 45° and 50°). They are commonly erect, except for a slight curvature in the plane normal to the flat side in the early growth stages, and have a height of up to 14mm and a breadth of up to 12mm. The calice is deep, with the deepest part near the middle of the curved side. Its margin is always slightly tilted down away from the flattened surface. The exterior shows growth annulations. The operculum is semi-elliptical with none of its other characters observable. In transverse sections of the corallites, seven septa can be distinguished within the dense sclerenchyme which completely fills the lumen on each side of the large fusiform counter septum on the flat side. No septa have been recognized with certainty on the curved side, but in parts of the sclerenchyme on the curved side of UQF53092 there are suggestions of indistinct radial plates. No horizontal skeletal elements can be recognized.

These sixteen specimens from B76F (see text-fig. 1) closely resemble the smaller individuals described as *C. sandalina alta* Richter by Hill (1942a) from the Givetian Burdekin Limestone of north Queensland.

**Remarks:**— Whitehouse (1929, p. 159) described *Calceola* sp. from the Ukalunda district; he considered it distinct from the *Calceola sandalina* group as it has markedly fewer septa. Reid (1930, p. 29) figured one of the specimens identified by Whitehouse; it appears to be conspecific with the smaller, more acute forms described from B76F, but recently could not be traced in the palaeontological collections of the Geological Survey of Queensland.

*Calceola* sp.

Pl. 4, fig. 7

A single transverse section UQF53399 from a pebble in the conglomerate at the base of the Drummond Group, 2.75 miles west of Pyramid homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 Sheet area, north Queensland, is referable to this genus. It shows the same internal structure as the large *C. sandalina* from the Middle Devonian part of the Broken River Formation and the Givetian Burdekin Limestone of north Queensland.

Genus RHIZOPHYLLUM Lindström, 1866

The two species described and placed in *Rhizophyllum* herein are representatives of morphological series in some respects intermediate between *Rhizophyllum* and *Calceola*. They have tabellae (and dissepiments?), but differ from typical *Rhizophyllum* in the possession of a continuous peripheral stereozone whose sclerenchymal structure is intermediate between that of *Calceola sandalina*, and that of the inconstant peripheral stereozone of *R. enorme* Etheridge.

It is possible that together with *Platyphyllum europaeum* Soshkina (1937) from the Gedinnian of



the western slopes of the Urals near Nizhneserginsk, *Calceola glossophylloides* Soshkina (1936) from the Eifelian *Calceola* beds of the northern Urals, and *Rhizophyllum mongolicum* Spasskiy (1960d) from the "Eifelian" of the Mongolian Altai, they should be grouped together in a genus distinct from *Calceola* and *Rhizophyllum*. This problem, however, together with the clarification of the characters of *Teratophyllum* Lang, Smith & Thomas, 1940 [*nomen novum* for *Platyphyllum* Lindström, 1883 *non* Audinet-Serville, 1831], to which they might prove referable, must await further work. The type species of *Teratophyllum* is the Wenlockian *Platyphyllum sinense* Lindström, 1883, from Szechuan, China.

*Calceola sandalina* "acuminata" of Soshkina (1949) from the upper Eifelian (*olim* Givetian) of the southern Urals (River Inzer), *Calceola macrovesiculosa* Markov (1926) from the lower Givetian? of the Urals, and *C. olegi* Chernyshev (1930) from the Eifelian of the Salair appear intermediate in their tabularial structures between the Australian species described herein and *Calceola sandalina*.

*Rhizophyllum ukalundense* sp. nov.  
Pl. 5, fig. 12

*Holotype*:— UQF53087, from B76F, Ukalunda Beds in Mary Creek, 'Hidden Valley', 8 miles north-northeast of Mt. Wyatt, Ukalunda district, southwestern part of Bowen 1:250,000 Sheet area, north Queensland; probably Couvinian.

*Diagnosis*:— Large solitary *Rhizophyllum*, turbinate in cardinal view, with a wide trabeculate peripheral stereozone, the trabeculae clearly forming septa on the flat side, but less regularly arranged on the curved side; dissepimentarium? and tabularium merge, plates somewhat thickened in irregular stereocones.

*Description*:— The holotype is a large calceoloid corallite flattened on its counter side, turbinate in cardinal view (apical angle  $90^\circ$ ), and curved in the plane at right angles to the flattened side so that in side view the corallite is convex towards the counter side. The corallite is 38mm in height, measured from apex to the top of the calical rim on the flattened side, and has a maximum diameter of 53mm just below the calical rim on the counter side. The exterior, where visible, shows fine growth lines superimposed on large irregularly developed growth annulations. No longitudinal striations could be distinguished on the external surface. There is no evidence of any radicle-form processes. The calice is moderately deep and steeply tilted down from the flattened side so that the curved edge is much shorter than the flat edge. The deepest part of the calice is near the middle of the curved face, and the curvature of the floor increases towards this pit. The counter side of the calice is traversed by longitudinal ridges, whereas the semi-circular surface is comparatively smooth. No operculum is known.

In transverse section, the corallite is semicircular with the corners at the junction of the flat and the curved faces well rounded. The epitheca is preserved only in isolated parts and appears quite thin. Inside

the epitheca is a wide dense stereozone which is thickest at the angles, thinnest on the curved side, and on the flattened side consists of coalescing septa of two clearly differentiated orders. The 21 major septa on each side of the large median counter septum extend to the inner edge of the stereozone. The minor septa are one-third as long as the major septa. The counter septum is fusiform, and is considerably longer than the other major septa, extending half the way to the centre of the calical pit. The stereozone of the curved side is composed of trabeculae set in lamellar sclerenchyme, but it is difficult either to differentiate individual septa, except in those places where there are alignments of the trabeculae at the periphery, or to determine whether two orders are developed. In longitudinal section, the lumen is filled with large, elongate, only slightly curved plates that are not clearly differentiated into dissepiments or tabulae. In the apical parts, the dissepiments are steeply inclined on both the counter and cardinal sides, with the intervening tabulae almost horizontal. Closer to the calyx, the outermost plates on the counter side are more steeply inclined than those on the counter side so that the dissepimentarium and tabularium merge; the central plates are concave distally. The floors of horizontal skeletal elements are steeply downwarped beneath the deep calical pit. Periodically, the skeletal thickening that is continuous with the peripheral stereozone spreads out onto the adjacent dissepiments? or tabulae, so that irregular surfaces of skeletal thickening can be differentiated representing previous positions of the calice.

*Microstructure*:— The septa are acanthine with relatively slender trabeculae embedded separately in lamellar sclerenchyme. The lamellae arch up and about the trabeculae and are continuous from septum to septum. Within a septum, the main plane of the lamellae is normal to the trabeculae. The trabeculae do not appear to be simple monacanth, as no regular simple linear axis or chevron arrangement of fibres is obvious. They are variable in diameter up to 0.12mm and in longitudinal section show dark irregular axes in transmitted light. They are more slender than the typical rhabdacanths of *Tryplasma*, and the 'rods' or axes of secondary trabeculae so characteristic of rhabdacanths cannot be differentiated with certainty. However, in some of the wider trabeculae at points of expansion of the axes, there is a suggestion that secondary trabeculae may be originating, and in transverse sections of the trabeculae, up to five centres from which the fibres seem to radiate can be resolved within the dark axis of a single trabeculae. Three interpretations are possible. In the first, the trabeculae can be interpreted as very slender rhabdacanths in which the axes of the secondary trabeculae are very short and diverge from the primary axis at a low angle. In the second, the axis of the "secondary trabeculae" are infinitesimally short so that the "secondary trabeculae" are merely tufts. In the third, they can be interpreted as originally normal stout rhabdacanths whose appearance has been changed during diagenesis, wherein the outer parts became continuous with the lamellar sclerenchyme; only the central area, corresponding to the axis of the primary trabeculae and the bases of the secondary trabeculae, remained unaltered.



This last interpretation is supported by the occasional presence of slender holacanthi representing further change in which the dark central axis is converted to a solid rod of clear calcite. More material is needed to resolve the problem.

The arrangement of the trabeculae is variable throughout the corallite. In the large counter septum, the trabeculae radiate upwards and outwards from a plane in the central region of the septum. In median longitudinal section, the trabeculae are fanned with the axis of divergence midway between the periphery and the inner edge of the septum. In this section the lamellae give an overall concentric pattern. Similar patterns of trabecular and lamellar arrangement, but with narrower fans, show in longitudinal sections normal to the median plane of the septum. In longitudinal sections parallel to, but distant from, this median plane, the cut ends of the trabeculae as seen in transmitted light show as dark centres surrounded by the clearer lamellar sclerenchyme; the centres are arranged in concentric patterns, parallel to the growth lines and the lamellae of the lamellar sclerenchyme, as shown in the inner parts of the septum; the lamellar sclerenchyme is clear and does not show any trace of the cut edges of lamellae, probably because the lamellae are parallel to the surfaces of the septum. In transverse section, the trabeculae show as circular dark centres in the middle of the septum, becoming elongate radially towards the outer parts. In the septa on each side of the counter septum, the trabeculae are arranged in a single plane; they are neither arched laterally as in the counter septum, nor are they arrayed fanwise, but are inclined inwards and upwards from the periphery, with the angle of inclination to the epitheca large and increasing with growth, so that in the inner part of the stereozone the trabeculae are nearly horizontal (compare pl. 5, fig. 12g with fig. 12f). In the stereozone on the curved side, the trabeculae slope upwards and inwards and are not regularly arranged; they seem to be less widely spaced than those in the septa of the flat side. Only at the periphery do several trabeculae seem to lie in one radial plane.

The sclerenchyme forming the thickening on the horizontal plates in the lumen is continuous and identical with the lamellar material of the septa. The lamellae parallel the dissepiments and tabulae, but in longitudinal section are periodically disrupted by short trabeculae. These are essentially of the same structure as the fine trabeculae of the septa.

*Remarks:*— *Rhizophyllum ukalundense* resembles the "Eifelian" *R. mongolicum* Spasskiy (1960d, pl. 6, figs. 1a-e) from the Sara-Gobi River, Mongolian Altai. Spasskiy's figure (pl. 6, fig. 1d) shows a well developed continuous stereozone similar to that of *R. ukalundense*, but the septa are much more clearly defined within the sclerenchyme on the curved side of the corallite. In his figure (pl. 6, fig. 1g), also from the holotype, the stereozone is less continuous, and more like that of *R. enorme* (Etheridge). The north Queensland form differs also from the Mongolian form in that the tabellae (and dissepiments?) are larger and not so closely packed.

*Rhizophyllum* sp. cf. *R. calceoloides* Talent, 1963  
Pl. 4, fig. 8

*Material:*— One specimen, UQF50517, from a small limestone lens at the base of the Broken River Formation, 0.5 miles east of Martin's Well, Pandanus Creek station, 150 miles northwest of Charters Towers, north Queensland; latitude 19° 16'S, longitude 144° 47½'E; Lower Devonian (Emsian?).

*Description:*— The specimen is a weathered, solitary flattened, calceoloid corallite with maximum length along the flattened side of 19mm and a width of 6.6mm. The external characters are not known. The lumen is bordered by a thick stereozone up to 2.6mm in width on the flattened side, and 1.5mm on the semicircular side. Within the stereozone, septa can be recognized especially on the flat side where there are 13 on each side of the large central fusiform septum which is probably the counter septum. The septa on the curved side are indistinct, their trabeculae becoming irregularly arranged axially. The septa consist of trabeculae, probably rhabdacanthi, set in fine lamellar sclerenchyme. The lumen is filled with thin horizontal skeletal elements of slight curvature.

*Remarks:*— This specimen closely resembles *Rhizophyllum calceoloides* Talent from the Lower Devonian Kilgower Member of east Gippsland, Victoria. It differs in transverse section only in being less globose than the Victorian form. More material might prove the north Queensland and Victorian forms to be conspecific.

Talent (1963) considered faunas of the Kilgower Member of the Tabberabbera Formation to be Emsian; in 1965 he thought them to be of lower Emsian aspect. Philip & Pedder (1968) referred this member to the Lower Devonian but showed it as Siegenian in their table.

|          |                                  |
|----------|----------------------------------|
| Order    | TABULATA Edwards and Haime, 1850 |
| Suborder | FAVOSITINA Wedekind, 1937        |
| Family   | FAVOSITIDAE Dana, 1846           |
| Genus    | FAVOSITES Lamarck, 1816          |

*Favosites* sp. cf. *F. goldfussi* d'Orbigny, 1850  
pl. 6, figs. 1, 2.

*Material:*— Two specimens, UQF52182-3, from the Ukalunda Beds at B84F (see text-fig. 1); probably Couvinian.

*Shape:*— One colony begins with a rapidly expanding cone and spreads rather suddenly into a tabular form with diameter at least 210mm. The second is a fragment of a colony attached to a rugose coral.

*Dimensions of "adult" corallites:*— The range of maximum diameter (median line to median line of wall, corner to corner) for 20 adult corallites in the large fragment is 1.6 to 2.9mm, with an average of 2.25mm; in the second colony it is 2.3 to 3.3mm, with an average of 2.7mm. The range of minimum diameter (median line to median line, side to side) in the larger colony is 1.33 to 2.33mm, with an average of 1.8mm; in the small fragment it is 1.7 to 3.1mm, with an average



of 2.44mm. The average adult corallite diameter in the larger colony was thus 2mm, and in the smaller fragment 2.6mm. In parts of the larger colony, all the corallites were smaller in diameter than in other parts. Tabular spacing (average of 20 corallites) is 14 in 10mm in the large colony, 20 in the small fragment. The wall thickness ranges from 0.05 to 0.18mm in the large colony, with an average of 0.12mm in 20 corallites, and from 0.08 to 0.23mm with an average of 0.13mm in the smaller fragment. Mural pores, in 2 to 3 alternating vertical rows to each corallite face, range from 0.125 to 0.25mm in diameter, the larger pores being the more common; distance between centres of pores in the vertical row ranges from 0.5 to 0.66mm.

*Description*:— The corallites are moderately large, average diameter 2.25 to 2.7mm; in parts of the colony the diameter of the average adult corallite may be smaller than in other parts, so that a considerable range in corallite diameter must be admitted for the species. The adult corallites are five to seven-sided, and young corallites are three to five-sided; the sides are straight or slightly curved. The walls show a median dark line in transmitted light, with fibres proceeding from it towards the lumen; in some walls, growth lines subparallel to the median dark lines are traceable across the fibres. As seen in transverse section of the walls, the fibres are generally grouped; and each group, as seen in longitudinal section of the walls, represents the base of one very short conical trabecula or blunt spine. These spines are so short that cross sections of them are rarely seen in longitudinal sections of the corallites. The spines project almost horizontally, or with a slightly upward tilt from the wall, and commonly arise, as do squamulae, in pairs, opposite one another on each side of the median line of the wall. In one tangential section, the points of seven such spines were intersected in an irregularly horizontal row across 1.25mm of a corallite of width 1.87mm. No horizontally elongate sections, characteristic of squamulae in such tangential sections, have been noted. The longest spine observed was 0.27mm. The junction of the walls is rounded by slight elongation of the fibres in only a few instances; the normal condition is angulate. The mural pores, when surrounded by thickened spine bases, widen towards the corallite axis as the spines taper. Many are open, but some have partial, or perhaps total, thin diaphragms in the plane of the mid-line of the walls. The pores are present on the faces only, not at the angles of the corallites. The tabulae are thin, horizontal, or very slightly saucered; a few are incomplete; a few show a median or submedian semicircular (or subcircular) section, below the plane of the tabula, and commonly open upwards; one case was seen where a circular section was closed and hung below the tabula like a bubble. The tabulae show low wide flutings peripherally, giving peripheral semicircular sections in some transverse sections of the corallites.

*Comparison*:— The specimens bear some resemblance to *Favosites goldfussi* d'Orbigny as figured by Jones (1936, pl. 2, figs. 8-10) from the Eifelian? *Calceola* beds of Gerolstein in the Eifel, in possessing broadly based spines; but in the German species the spines narrow only slightly from base to axial end,

and are uniformly longer than those of the Ukalunda specimens. The range of corallite diameter is somewhat smaller in the Australian species; the two to three rows of pores are similar. The tabular form differs from the spherical to mushroom form of the Eifel specimens. Our specimens are quite similar to those described as *F. goldfussi* forma *regularis* by Lecompte from the upper part of the upper Couvinian of the southern border of the Dinant Basin, Belgium. They are also similar to the specimens figured by Sokolov (1952, pl. 1, figs. 1-4; pl. 2, fig. 1) from the upper Eifelian *Calceola* and Biya beds of the western Urals, and by Dubatolov (1959, pl. 8, figs. 1, 2) from the Salairka beds of the Salair. The Salairka beds are correlated by Rzhonsnitskaya (1962) with the *Paraspirifer cultrijugatus* beds of western Europe, i.e. with the lower Couvinian.

#### Genus SQUAMEOFAVOSITES Chernyshev, 1941

*Type Species* (by original designation):— *Favosites hemisphaericus* var. *bohemicus* Potca, 1902, upper Koneprus Limestone, Koneprus, Czechoslovakia; Lower Devonian, f<sub>2</sub> Praguian (= upper Siegenian and lower Emsian). For redescription of original material see Kraicz (1937).

*Diagnosis*:— Corallum favositoid, walls of corallites somewhat thickened; squamulae more common than spines; pores commonly large.

*Distribution*:— Europe and Asia, high Upper Silurian to lower Middle Devonian; Australia, North America, and northwest Africa, lower Devonian to lower Middle Devonian.

*Remarks*:— This genus, which differs from *Favosites* in the presence of septal squamulae that outnumber septal spines, and which is characterized also by somewhat thickened walls, and by rather large mural pores confined to the prism faces of the corallites, is valuable stratigraphically in that it has a relatively limited range, upper Ludlovian to Eifelian, and is most common in the Lower Devonian. The Australian species described by Philip (1960) as *Favosites squamuliferus* and as formae of *F. squamuliferus* belong to it. Speciation within the genus in Australia and New Zealand cannot be achieved without a full-scale revision of the type specimens, accompanied by variation studies of topotypic specimens. Materials are being accumulated for such a study, and taxonomic revision of the genus is left to a later occasion. The Ukalunda specimens falling within the genus are fairly sharply differentiated into the two common Australian species, *S. nitidus* (Chapman) and *S. bryani* (Jones).

#### *SquamEOFavosites nitidus* (Chapman)

Pl. 6, fig. 3, pl. 7, fig. 1

*Lectotype*:— Chosen Hill & Jones (1940, p. 198), and figured Hill & Jones (1940, pl. 6, figs. 3a, b, c); National Museum Melbourne MD749 with two slides 1335; limestone behind Cooper's Creek Copper Mine, Walhalla, Victoria; Lower Devonian, probably Siegenian.



**Diagnosis:**— *Squameofavosites* with corallites ranging from 0.5 to 0.8mm in diameter, commonly with one row of large, circular to suboval pieces in each face of the corallite; on parts of some faces, two alternating rows of smaller pores.

**Remarks:**— Six specimens, UQF40314, 52809-11, 52819, 52843, are present in the collections from Ukalunda, all from B76F (see text-fig. 1); probably Couvinian. Their form is tabular, but with growth somewhat extended upwards to give a rather flat calicular surface and a cake-like appearance.

The species is common in the Siegenian, Emsian, and early Couvinian? of eastern Australia. Philip (1960) referred to it as *Favosites squamuliferus* forma *nitidus* (B) and listed previous references.

Of overseas species, *Favosites alpinus* Hornes in Penecke (1894, pl. 9, figs. 13, 14) from the Lower or lower Middle Devonian *Barrandei* beds of the Breithamhalt, Graz, Austria, (lectotype refigured and described by Schouppé (1954, pl. 1, figs. 4, 10)) has similar form and dimensions, but it is not clear whether the "Knotchen" mentioned by Schouppé are squamulae or not. According to Boroviczény & Flügel (1962), *Favosites ottiliae* Penecke (1894) shows no significant biometric difference from *F. alpinus*, and is its synonym. *Squameofavosites brusnitzini* (Peetz) as figured by Chernyshev (1951, pl. 5, figs. 3-5), Dubatov (1956, pl. 2, figs. 1, 2), and Dubatov and Mironova (1961, pl. D18, figs. 3a, b) from the probably Siegenian Krekov Beds of the Kuznetsk Basin, the northeast PreSalair, and the Salair is very similar, though with slightly greater diameter of corallites. *Favosites sublatus* Dubatolov (in Rzhonsnitskaya *et al.*, 1952, pl. 2, figs. 1-2) and of Dubatolov & Mironova (1961, pl. D-16, figs. 4a, b) from the Tashtyp suite of the Minussinsk depression is of similar size, but the nature of its squamulae (or spines?) has not been made clear.

*Squameofavosites bryani* (Jones)  
Pl. 7, figs. 2, 3

**Holotype** (by original designation):— Australian Museum AMF5550 from the Devonian of Goodhope, near Yass, New South Wales; (Jones, 1937, p. 96, pl. 15, figs. 3, 4).

**Diagnosis:**— *Squameofavosites* with thick-walled (average 0.125mm) polygonal corallites of average diameter 1.4mm, with a single median row of circular to suboval mural pores (average diameter 0.25mm, average distance between centres 0.6mm); with the fibres of the septal trabeculae, at the upper and sometimes at the lower rims of pores, grouped in long, sharp-edged, eaves-like squamulae; discrete septal spines also occur at the sides of the mural pores. Tabulae numerous (up to 18 in 5mm), usually complete and horizontal, sometimes inclined or sagging and suspended from squamulae.

**Remarks:**— This species is common in eastern Australia in Siegenian, Emsian and lower Couvinian Limestones. Philip (1960, p. 197) referred to it as *Favosites squamuliferus* forma *bryani* Jones (forma) and gave a list of previous references to it and related species.

Four specimens, UQF52820, 52844-6, from B76F (see text-fig. 1), and one, UQF52832, from B84F (see text-fig. 1) are referred to this species. The average diameter for adult corallites measured on the slides of two of the paratype specimens (from the Yass end of the Old Taemas Bridge) is 1.4mm, on the method of averaging adopted by the present authors, against 1mm on the method used by Jones. It is thus clear that authors should state their methods of measurements and that a standard international method is desirable.

Dubatolov (1963, p. 39, pl. 15, figs. 2-4) has drawn attention to the similarity between *Squameofavosites sokolovi* Chekhovich, from the Manak Beds of the Lower Devonian of south Ferghana, and *S. bryani*. He stated that *S. sokolovi* differs in having rounded pores only, and in having only thick squamulae with no accompanying septal spines. Dubatolov reported the species from the Tom-Chumysh (Tiverian=Gedinnian) and Krekov Beds (Siegenian?) of the Kuznetsk Basin. He also drew attention to the close similarity between *Squameofavosites pluteus* Hill (1950, p. 151, pl. 8, figs. 25, 26), an associate of *S. bryani* in the Emsian or lower Couvinian? upper part of the Murrindal Limestone, Rocky Camp, Buchan Victoria), and *S. frequens* Smirnova MS in Dubatolov (1963, p. 47, pl. 19, figs. 2, 3) from the Lower Devonian of the Tarei River in central Taimyr, and from the Lower Devonian and lower Middle Devonian of southern Siberia. Dubatolov and Smirnova (1964, p. 41, pl. 1, fig. 4; pl. 2, figs. 1, 2) gave further information on *S. frequens*.

For discussion on the age of the strata of the Buchan district, see Teichert and Talent (1958), Talent (1965, 1967), Philip (1966), and Philip and Pedder (1967b, 1968).

|        |                             |
|--------|-----------------------------|
| Family | PACHYPORIDAE Gerth, 1921    |
| Genus  | THAMNOPORA Steininger, 1831 |

*Thamnopora?* sp.  
Pl. 9, figs. 1, 7, 8

**Material:**— Two fragments, UQF52814, 5 from B76F (see text-fig. 1) and one, UQF52816 from B84F (see text-fig. 1); probably Couvinian.

**Description:**— The fragments are of palmate fronds only 2.5mm thick; at positions of dichotomy, the width may be as much as 12.5mm. The fragments are too worn to give any certain knowledge of the shape of the calical openings, but from the thin sections prepared, there seems no reason to suppose that the openings were restricted transverse slits such as occur in the Silurian *Coenites linearis* Edwards and Haime. Tangential sections suggest that the openings were circular, due to thickening of the wall rounding the angles of the polygonal corallites.

The corallites diverge to each surface of the frond somewhat irregularly from the median plane, there being no sharp line of division between the corallites proceeding to the two faces. In the median region, the median dark lines of the common walls indicate polygonal corallites with one or more of the walls slightly curving; the curvature, however, is not in any regular pattern such as is characteristic of *Alveolites*. Two or three rows of corallites are present in the



median zone and even there, the common walls are markedly thickened — 0.075mm to 0.1mm in corallites ranging from 0.25mm to 0.375mm in diameter. From this median zone, which may be 0.875mm wide, the corallites diverge somewhat sharply to open about 40° to the surface, their diameter increasing slightly as they approach the surface; at the same time, the thickening of the common walls increases, so that the lumen of the calices is about 0.25mm in a calice 0.75mm wide. The specimens are so weathered that the microstructure of the walls is not discernible. Mural pores are fairly common in the median zone and rather large. Tabulae are rare, horizontal. Septal spines have not been distinguished with certainty.

Genus CLADOPORA Hall, 1851

*Cladopora* sp.

Pl. 9, figs. 2-6

**Material:**— Rather weathered fragments, UQF52800-8, from B76F (see text-fig. 1), and two, UQF52799, 52817, from B84F (see text-fig. 1); probably Couvinian.

**Description:**— The fragments are all of slender, straight, almost cylindrical, forking branchlets that range in diameter from 1.45 to 3mm. The calices are oblique, and have a slightly projecting lower lip; the openings are somewhat kidney-shaped, or subcrescentic, about 0.45mm wide. A few rough septal striae are observed in subtangential section of 5 corallites of UQF52801, and short septal striae present also in UQF52802.

In the axial parts of the branches, the corallites are relatively thin-walled and are subvertical; they curve inwards, slightly at first and then somewhat more rapidly, to open at the surface at about 45°. In longitudinal sections, 3 to 4 corallites are seen in the axial zone (0.625mm in a branch of 2.1mm diameter); in the transverse sections, they are somewhat irregularly polygonal, four to six-sided, with angles rounded to a degree by sclerenchyme. The thickening increases gradually towards the calical openings where the common wall between two corallites may be 0.2 or even 0.3mm thick. The lumen in the principal zone becomes cylindrical due to this thickening. The corallites arise in the axial zone, where they may be 1.25mm long or more; in the peripheral zone, they are approximately 2mm long. Their width in the axial zone is 0.125 to 0.225mm. Only one undoubted tabula has been noted (in UQF52806); mural pores are sparse, and septal striae rare and sporadic in occurrence.

**Comparison:**— The occurrence or rare septal striae, rare tabulae, and the greater degree of thickening distinguishes this species from the type species *Cladopora seriata* Hall (described by Oliver (1963)) from the Silurian Lockport Dolomite of New York, U.S.A. In these features, our species resembles *Thamnopora*, but in view of its small dimensions and the poor preservation of the material, it is referred for the present to *Cladopora*.

Of the Australian species, it is close to *Cladopora gippslandica* (Chapman), as figured by Philip (1962, pl. 18, figs. 1, 6, 7) from the Gedinnian? Boola Beds, Tyers River area, Victoria. However, Chapman (1907)

described his type specimens as having calical openings taller than wide, and in the Queensland material the openings tend to be transverse.

Family ALVEOLITIDAE Duncan, 1872

Genus ALVEOLITES Lamarck, 1801

**Type Species** (by subsequent designation):— *A. suborbicularis* Lamarck (1801, p. 375), Upper Devonian, near Dusseldorf, Germany; chosen Nicholson & Etheridge, 1877.

*Alveolites* sp. cf. *A. stamineus* Hill, 1950

Pl. 8, figs. 1-6; pl. 9, fig. 11

**Material:**— Five specimens, UQF52432, 52821, 52830, 52831, 52837, from B76F (see text-fig. 1), and two, UQF52833, 52835, from B84F (see text-fig. 1); probably Couvinian. The sections obtained are all oblique, so that the average dimensions given below are only approximate.

**Description:**— The corallum is plate-like, spreading subhorizontally in a series of expansions discontinuous each from the earlier in the peripheral regions of the colony; each such lamella-like expansion is of the order of 3mm thick. The corallites grow more outwards than upwards and are inclined at an angle of about 30°. Those of the lower of the two basal rows in each such expansion run almost horizontally, and have thinner walls than the more inclined corallites above them, and to which they give rise.

The average maximum distance between upper and lower walls of the corallites in the oblique, suboblique and sublongitudinal section available is about 0.25mm, but some distances of 0.35mm have been measured. In subtransverse sections of the inclined corallites, the greatest width of the corallites is about 0.625mm, and the average width is probably 0.6mm. These dimensions are somewhat smaller than those of the holotype of *A. stamineus*.

The inclined corallites are thick-walled, from 0.05 to 0.1mm or 0.125mm and the "median dark line" of the common walls is commonly submedian. The corallites are alveoliteoid in transverse sections, with the side walls of the upper corallites resting on the tops of the arches of the corallites in the row below. Septal spines are common, not differentiated in size between upper and lower walls, short and rather thick. No enlarged spines rising from the lower wall have been noted. Mural pores are large, located in the side walls at the junctions with the walls of the corallites below, and somewhat sparse. Tabulae are variably developed, in one corallum 15 in a corallite with a length of 2.5mm; in another, 8 in the same length; they vary from slightly convex to slightly concave, from horizontal to inclined, and in some corallites incomplete plates supplement complete plates.

**Remarks:**— The material is close to *A. stamineus* morphologically, but the corallite dimensions and wall thickness are somewhat smaller. *A. stamineus* was described from the Emsian or Couvinian upper Murrindal Limestone of the Buchan district, Victoria.

A single slide, UQF52834 (pl. 9, fig. 11), shows an oblique longitudinal section through a very thin



spreading corallum whose sheets are only one or two corallites thick. The corallites are less stable in their form than those of the one or two basal, horizontal rows of corallites in *A. stamineus*, and as a result, look more flexuose. In dimensions, they are rather similar. In places, there are a few corallites with thickened walls lying above the basal rows, suggesting that the thin expansions may be but the basal rows of corallites of an alveolitid, possibly *A. sp. cf. A. stamineus*. No undoubted mural pores have been noted, and it is possible that the slide may represent an aulopodid.

A specimen, UQF53398 (pl. 8, fig. 5), from a pebble at the base of the Drummond Group, 2.75 miles west of Pyramid homestead, Ukalunda district, may be conspecific with the specimens from B76F and B84F.

Suborder HELIOLITINA Okulitch, 1936  
Family HELIOLITIDAE Lindström, 1876  
Genus PSEUDOPLASMOPORA Bondarenko, 1963

*Type Species* (by original designation):— *P. conspecta* Bondarenko (1963, p. 47, pl. 4, fig. 1, text-fig. 1). Holotype, Moscow State University No. 46/1a-zh; central Kazakhstan, about 3 kilometres to the north of Akbastau; Ludlovian, top of Isenian suite.

*Diagnosis*:— Corallum of variable form. Walls of corallites smooth (without trace of faceting) or folded. Septal structures, when present, either plates or spines. Corallites surrounded by an aureole of 12 tubules of varying radial extent; remainder of intercorallite structure also tubular. Tabulae normal, and diaphragms of tubuli complete and horizontal.

*Distribution*:— USSR, Middle and Upper Silurian; eastern Australia, Lower Devonian.

*Remarks*:— Bondarenko (1963) distinguished this genus from the Silurian *Plasmopora* Edwards and Haime (type species *Porites petalliformis* Lonsdale) by its possession of tubuli with continuous walls, like those of *Heliolites*; in *Plasmopora* the spaces between aureoles are occupied by globose, dissepiment-like plates that may be arranged in vertical series, and that leave in some places vertical series of aculae arranged into discontinuous walls of partial tubuli. Bondarenko gives the range of the species with continuous walls as Middle and Upper Silurian, and states that she considers the eastern Australian Devonian species, e.g. *P. gippslandica* (Chapman), to have the walls of the tubuli thickened, particularly at the junctions of faces, to give cylindrical or subcylindrical lumina. However, the individual described herein from the Ukalunda Beds has the walls of the tubuli only slightly thickened, and the lumina are still polyhedral. Discussion of the relative merits of Lindström's and Bondarenko's family and generic classification is left to a later occasion.

*Pseudoplasmopora sp. cf. P. gippslandica* (Chapman, 1914)  
Pl. 9, fig. 10

*Material*:— One specimen, UQF52829, from B76F (see text-fig. 1); probably Couvinian.

*Description*:— A fragment, roughly 10cm x 8cm x 2cm, consists of tabularia ranging from 1.45 to 1.55mm, separated by 2 to 7 tubuli, and commonly by 3 to 4 tubuli; the distance between tabularial walls ranges from 1mm to 2.2mm, but is commonly 1.25mm to 1.75mm. The tabularial walls are round, without inflections, and may be a little thicker than the walls of the tubuli, an average of 0.05mm as against 0.025mm, though some tubuli may have parts of their walls as thick as 0.05mm, and some tabularia, as thick as 0.125mm. The tubuli are mainly polyhedral in transverse section, though some show curved regions resembling sections through a proporoid dissepiment. The thickening of their walls is not noticeably greater at the angles than on the faces, so that the lumina of the tubuli are not cylindrical.

The tubuli, of the aureole of 12, are perceptibly larger than the remaining tubuli; a few are slightly larger in the radial than in the circumferential direction, but not so markedly so as those of the specimen figured as *Plasmopora gippslandica* (Chapman) from the Couvinian of Johannsen's Caves, near Rockhampton, Queensland by Jones & Hill (1940, pl. 11, fig. 1).

Septal structures appear to be absent, but this may be due to poor preservation.

The tabulae are horizontal, oblique, or subconically depressed, and complete or rarely incomplete. The solenia are complete, and either horizontal or slightly concave or convex. In longitudinal section, the walls of the tubuli are straight, except for occasional indentations that occur at their junctions with solenia, as in *Plasmopora*.

The specimen, which is poorly preserved, falls within the limits of *Plasmopora gippslandica* (Chapman), as understood by Jones & Hill (1940). Chapman's specimens were from the probably Siegenian Cooper's Creek Formation of Victoria. We have this species under revision, but require better preserved material for an assessment of the relationship of the Ukalunda specimens to the Victorian topotypes.

Suborder AULOPORINA Sokolov, 1950  
Family AULOPORIDAE Edwards and Haime, 1851  
Genus AULOPORA Goldfuss, 1829

*Aulopora sp.*  
Pl. 9, fig. 9

One thin section of an *Aulopora*, UQF53349, from B84F (see text-fig. 1), the only material available, is figured herein. It is of the basal, anastomosing network of a colony encrusting an alveolitid. The reptant tubes are up to 0.45mm in diameter, with walls up to 0.125mm thick, and with sparse, somewhat convex tabulae, and small septal spinules.



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## EXPLANATION OF PLATE 1

Figs. 1-5. *Metriophyllum?* sp. *A.* Ukalunda Beds, B220F, 4.75 miles slightly north of west of the Pyramid homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; Devonian.

Figure 1—UQF53341; thin transverse section, X10.

Figure 2—UQF53342; thin transverse section, X10.

Figure 3—UQF53343, thin transverse section, a, X10, b, X20.

Figure 4—UQF53345; thin longitudinal section, X10.

Figure 5—UQF53344; thin longitudinal section, X10.

Figs. 6-12. *Cyathophyllum* (*Cyathophyllum*) *sentum* sp. nov. Ukalunda Beds, B76F, in Mary Creek, 'Hidden Valley', 8 miles north-northwest of Mt. Wyatt, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian.

Figure 6—UQF52708; a, thin transverse section, b, thin longitudinal section, X2.

Figure 7—UQF52712; a, thin transverse section, b, thin longitudinal section, X2.

Figure 8—UQF52710, HOLOTYPE; a, thin transverse section, b, thin longitudinal section, X2.

Figure 9—UQF40320; thin longitudinal section, X2.

Figure 10—UQF40322; thin transverse section, X2.

Figure 11—UQF52713; a, thin transverse section, b, thin longitudinal section, X2.

Figure 12—UQF52707; a, thin transverse section, b, thin longitudinal section, X2.



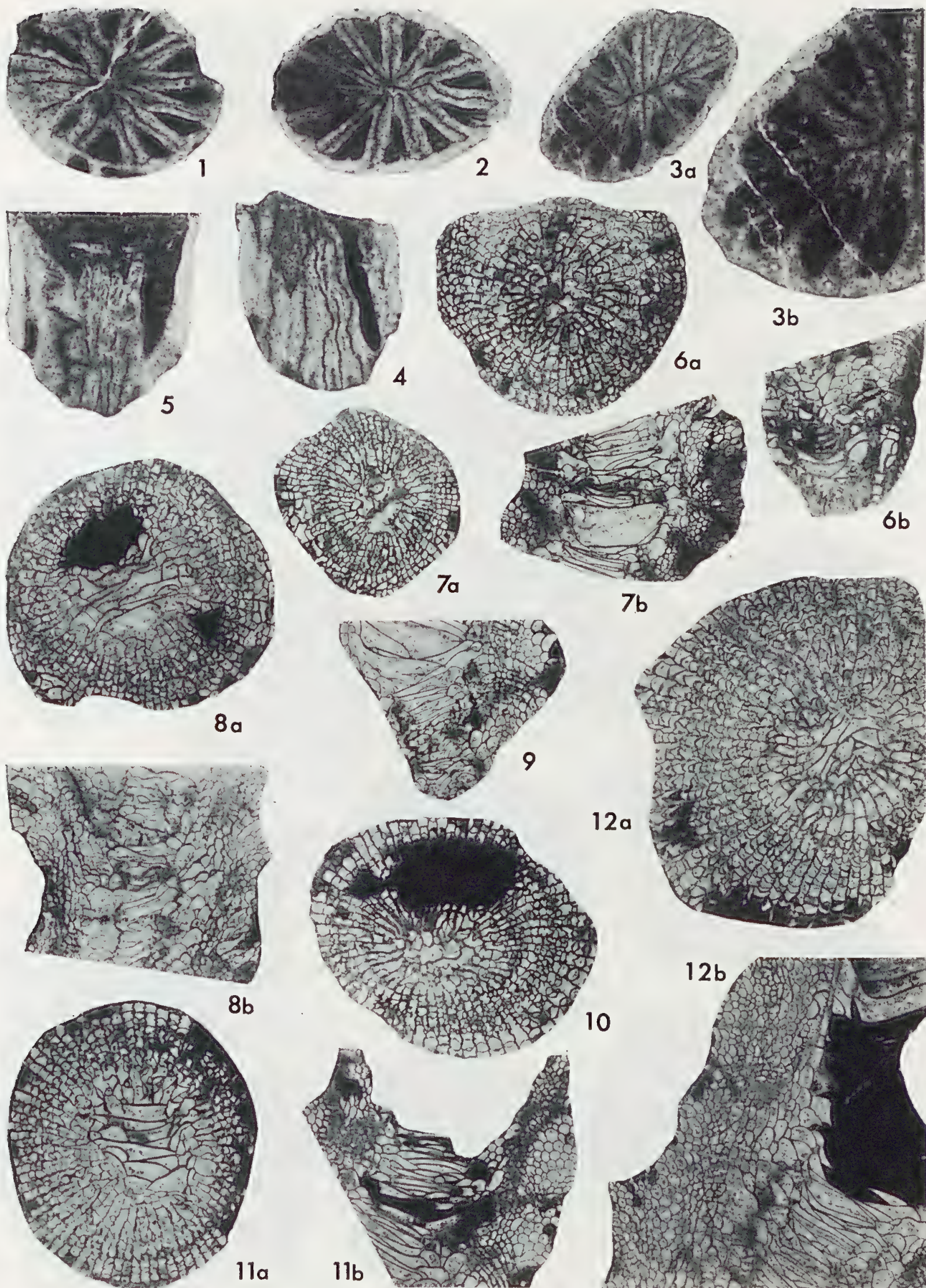


PLATE 1



## EXPLANATION OF PLATE 2

Figs. 1-3. *Phacellophyllum* sp. A. Limestone pebbles in the conglomerate at the base of the Drummond Group (*i.e.* probably in the Mt. Wyatt Beds), 2.75 miles west of the Pyramid homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland.

Figure 1—UQF53385; a, thin transverse section, b, thin longitudinal section, X4.

Figure 2—UQF53386; a, thin transverse section, b, thin longitudinal section, X4.

Figure 3—UQF53388; a, thin transverse section, b, thin longitudinal section, X4.

Figs. 4-6. *Ceratophyllum* sp. A. Ukalunda Beds, B76F, in Mary Creek 'Hidden Valley', 8 miles north-northwest of Mt. Wyatt, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian.

Figure 4—UQF52790; a, thin transverse section, b, thin longitudinal section, X2.

Figure 5—UQF52789; a, thin transverse section, b, thin longitudinal section, X2.

Figure 6—UQF52788; a, thin transverse section, b, thin longitudinal section, X2.

Fig. 7. *Ceratophyllum* sp. A? Ukalunda Beds, B84F, 2 miles slightly north of west of Hidden Valley homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian.

Figure 7—UQF52793; thin transverse section, X2.

Figs. 8, 9. *Temnophyllum?* sp. Locality as for figs. 4-6.

Figure 8—UQF52785; a, thin transverse section, b, thin longitudinal section, X2.

Figure 9—UQF52784; a, b, thin transverse sections, a X2, b X4, c, thin longitudinal section, X4.

Figs. 10-12. *Cyathophyllum* (*Cyathophyllum*) *pannosum* sp. nov. Locality as for fig. 7.

Figure 10—UQF52795; a, thin transverse section, b, thin longitudinal section, X2.

Figure 11—UQF52794; a, b, thin transverse sections, c, thin longitudinal section, X2.

Figure 12—UQF52798, HOLOTYPE; a, thin transverse section, b, thin longitudinal section, X2.



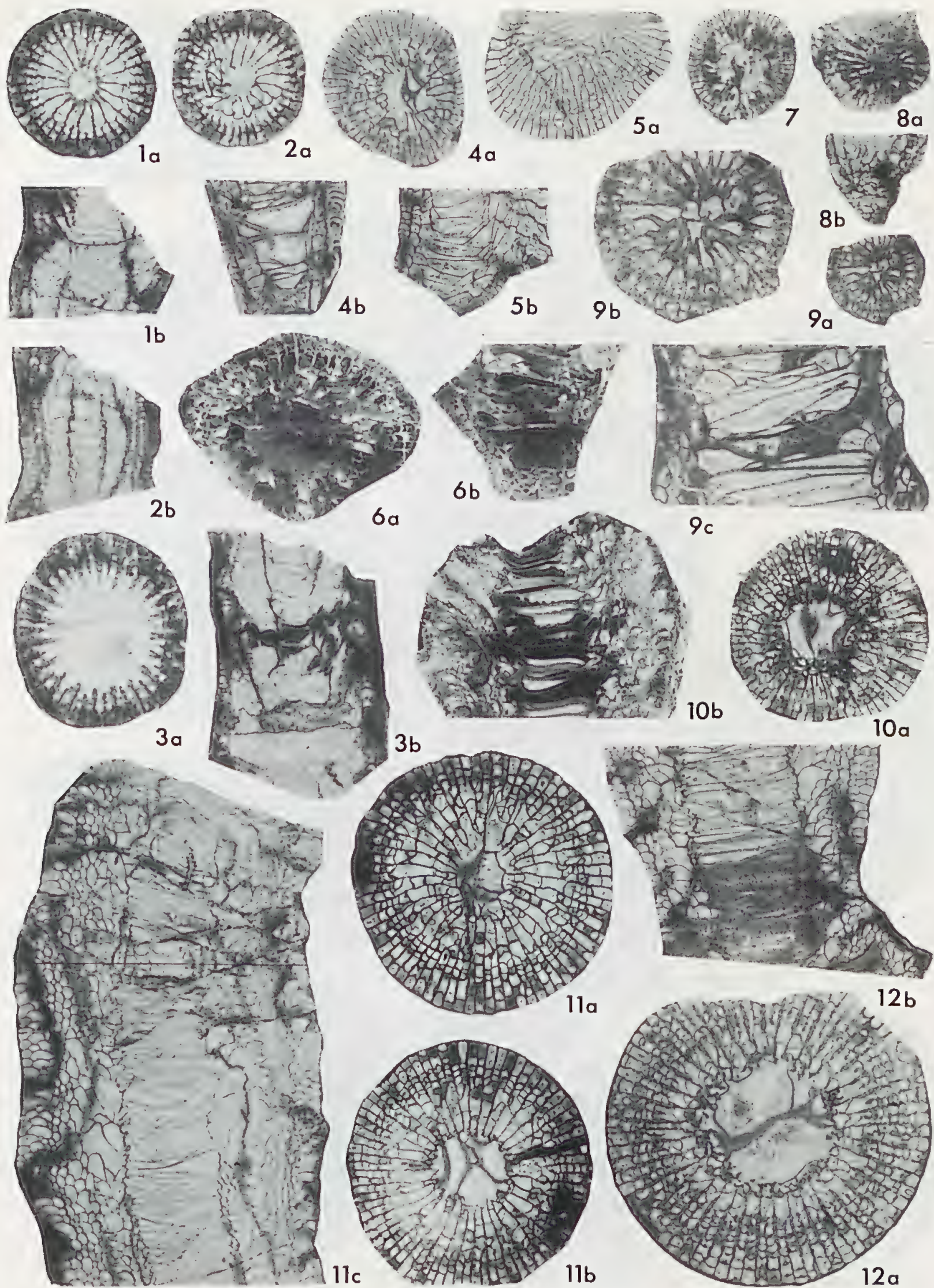


PLATE 2



### EXPLANATION OF PLATE 3

Fig. 1 *Gurieviskiella talenti* sp. nov. Ukalunda Beds, B84F, 2 miles slightly north of west of 'Hidden Valley' homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland, probably Couvinian.

Figure 1—UQF52773; a, thin transverse section, b, thin longitudinal section, X2.

Fig. 2. *Acanthophyllum* sp. Limestone pebbles in the conglomerate at the base of the Drummond Group (i.e. probably in the Mt. Wyatt Beds), 2.75 miles west of the Pyramid homestead, Ukalunda district, southwestern part of Bowen 1:250,000 sheet area, north Queensland.

Figure 2—UQF53397, thin transverse section, X2.

Figs. 3-8. *Gurieviskiella talenti* sp. nov. 3, 7, locality as for fig. 1, 4-6, 8, Ukalunda Beds, B76F, in Mary Creek, 'Hidden Valley', 8 miles north northeast of Mt. Wyatt, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian.

Figure 3—UQF52727; a, thin transverse section, b, thin longitudinal section, X2.

Figure 4—UQF40321; a, thin transverse section, b, thin longitudinal section, X2.

Figure 5—UQF52633; a, thin transverse section, b, thin longitudinal section, X2.

Figure 6—UQF40318; a, thin transverse section, b, thin longitudinal section, X2.

Figure 7—UQF52775, HOLOTYPE; a, thin transverse section, b, thin longitudinal section, X2.

Figure 8—UQF52776; a, thin transverse section, b, thin longitudinal section, X2.



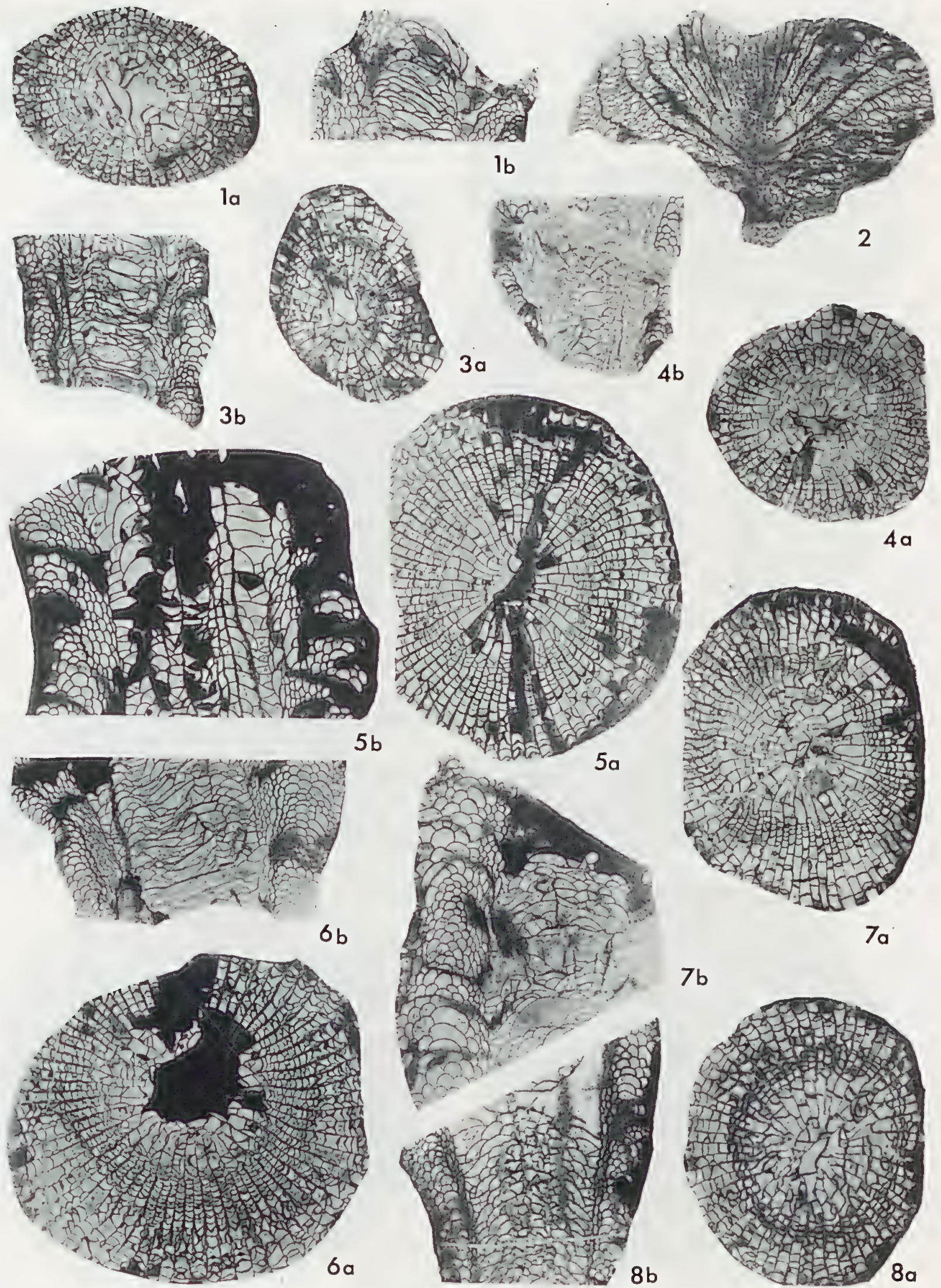


PLATE 3



#### EXPLANATION OF PLATE 4

Figs. 1-6. *Plasmophyllum* (*Plasmophyllura*) *magnivesiculosum* sp. nov. 1, 3, 5, Ukalunda Beds, B76F, in Mary Creek 'Hidden Valley', 8 miles north-northeast of Mt. Wyatt, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian. 2, 4, 6, Ukalunda Beds B84F, 2 miles slightly north of west of Hidden Valley homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian.

Figure 1—UQF52700; a, thin transverse section, b, thin longitudinal section, X2.

Figure 2—UQF52725; a, thin transverse section, b, thin longitudinal section, X2.

Figure 3—UQF52701; a, b, thin longitudinal sections, X2.

Figure 4—UQF52722; thin longitudinal section, X2.

Figure 5—UQF52699; a, thin transverse section, b, thin longitudinal section, X2.

Figure 6—UQF50902, HOLOTYPE; a, thin transverse section, b, thin longitudinal section, X2.

Fig. 7. *Calceola* sp. Pebbles in the conglomerate at the base of the Drummond Group (i.e. probably in the Mt. Wyatt Beds) 2.75 miles west of the Pyramid homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland.

Figure 7—UQF53399, thin transverse section, X4.

Fig. 8. *Rhizophyllum* sp. cf. *R. calceoloides* Talent. Small limestone lens at the base of the Broken River Formation, 0.5 miles east of Martin's Well, 'Pandanus Creek', 150 miles northwest of Charters Towers, north Queensland; Lower Devonian (Emsian?).

Figure 8—UQF50517; a, b, thin transverse sections, X4.

Fig. 9 *Tryplasma* sp. Locality as for fig. 7.

Figure 9—UQF53395; a, thin transverse section, b, thin longitudinal section, X2.



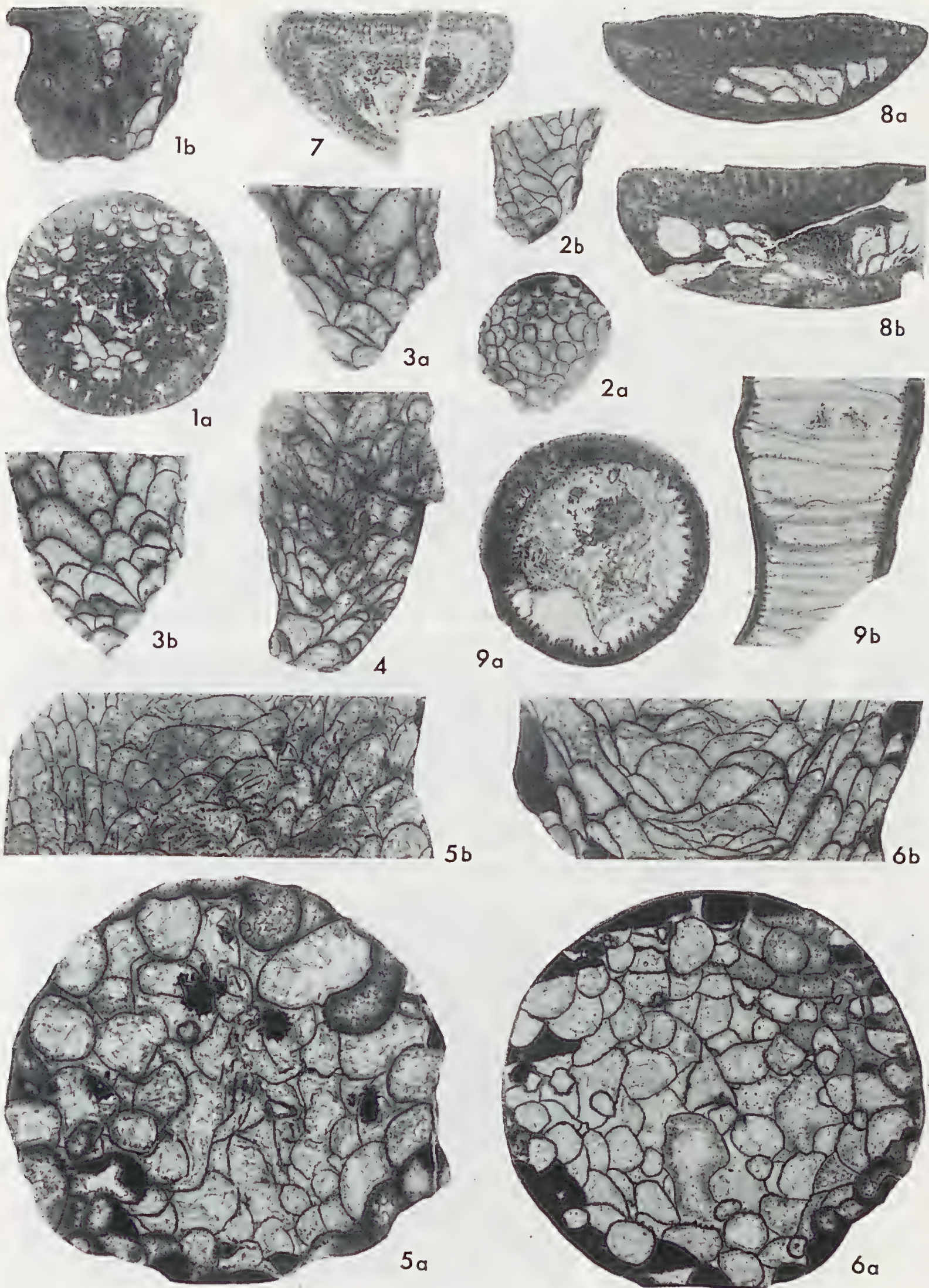


PLATE 4



## EXPLANATION OF PLATE 5

Figs. 1, 2. *Protomacgeea* sp. A. 1, Limestone pebbles in the conglomerate at the base of the Drummond Group (*i.e.* probably in the Mt. Wyatt Beds), 2.75 miles west of the Pyramid homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland. 2, lower part of the Chinaman Creek Limestone Member, Broken River Formation, 2.8 miles north of Pandanus Creek homestead, 150 miles northwest of Charters Towers, north Queensland; probably Couvinian.

Figure 1—UQF53396; thin transverse section, X4.

Figure 2—UQF49790; thin transverse section, X4.

Figs. 3-11. *Calceola sandalina* (Linnaeus). 3, 4, Eifel, Germany; Middle Devonian. 5-11, Ukalunda Beds, B76F, in Mary Creek, 'Hidden Valley', 8 miles north-northeast of Mt. Wyatt, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian.

Figure 3—UQF4815; a, thin transverse section, b, thin longitudinal section, X2.

Figure 4—UQF4811; thin longitudinal section, X2.

Figure 5—UQF53090; thin longitudinal section, X5.

Figure 6—UQF53089; thin longitudinal section, X5.

Figure 7—UQF53091; thin transverse section, X5.

Figure 8—UQF53092; thin transverse section, X5.

Figure 9—UQF53400; latex cast of external mould, X2.

Figure 10—UQF53093; a, side view of corallite, b, cardinal view of corallite, X2.

Figure 11—UQF53088; a-c, thin transverse sections at various growth stages of the corallite, X3.

Fig. 12. *Rhizophyllum ukalundense* sp. nov. Locality as for figs. 5-11.

Figure 12—UQF53087; a, external view of calyx, X1, b, thin transverse section towards the base of the calyx, X3, c, thin longitudinal section immediately adjacent to counter septum, X3, d, thin median longitudinal section through counter septum, X3, e, thin median longitudinal section through major septum along the flattened side of corallite, X3, f, enlarged section of fig. 12e, X20, g, enlarged section of fig. 12d, X20, h, thin transverse section below the calyx, X3, i, thin longitudinal section adjacent to the deep central calical pit, X3, j, thin longitudinal section through lateral part of the corallum, X3, k, thin longitudinal section through the deep central calical pit, X3.



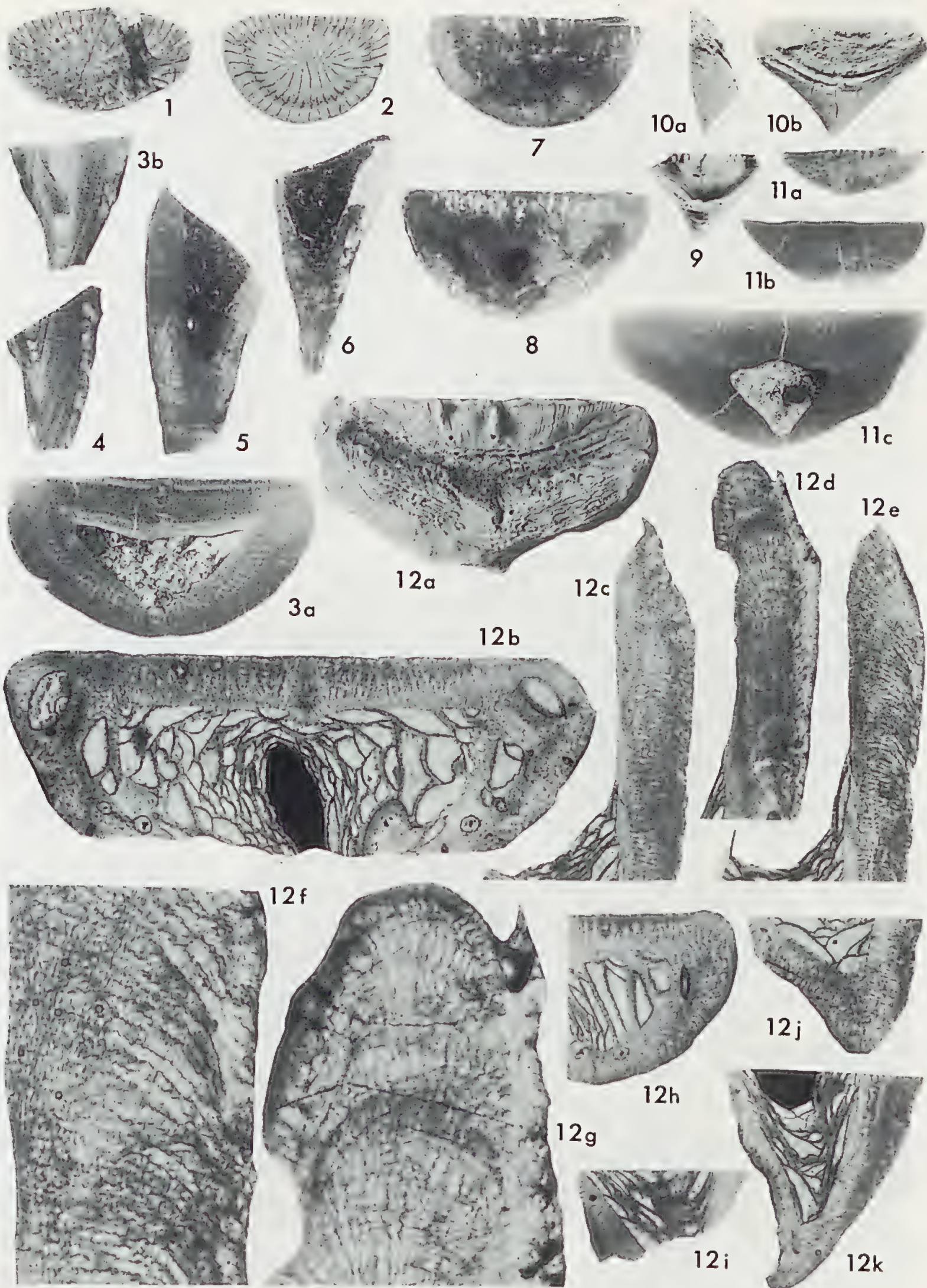


PLATE 5



#### EXPLANATION OF PLATE 6

Figs. 1, 2. *Favosites* sp. cf. *F. goldfussi* d'Orbigny. Ukalunda Beds, B84F, 2 miles slightly north or west of Hidden Valley homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian.

Figure 1—UQF52813; a, thin transverse section, X4, b, thin transverse section, X2, c, thin longitudinal section X2, d, e, thin longitudinal sections, X4.

Figure 2—UQF52812; a, thin transverse section, X4, b, thin longitudinal section, X4, c, thin section, X2.

Fig. 3. *Squameofavosites nitidus* (Chapman). Ukalunda Beds, B76F, in Mary Creek, 'Hidden Valley', 8 miles north-northeast of Mt. Wyatt, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian.

Figure 3—UQF40314; a, thin transverse section, X2, b, thin transverse section, X4, c, thin longitudinal section, X2, d, thin longitudinal section, X4.



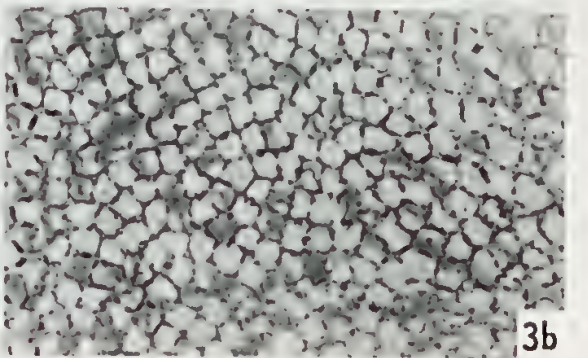
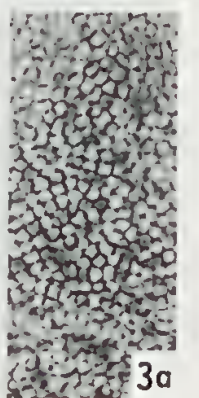
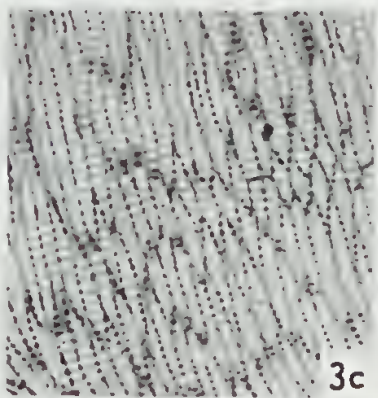
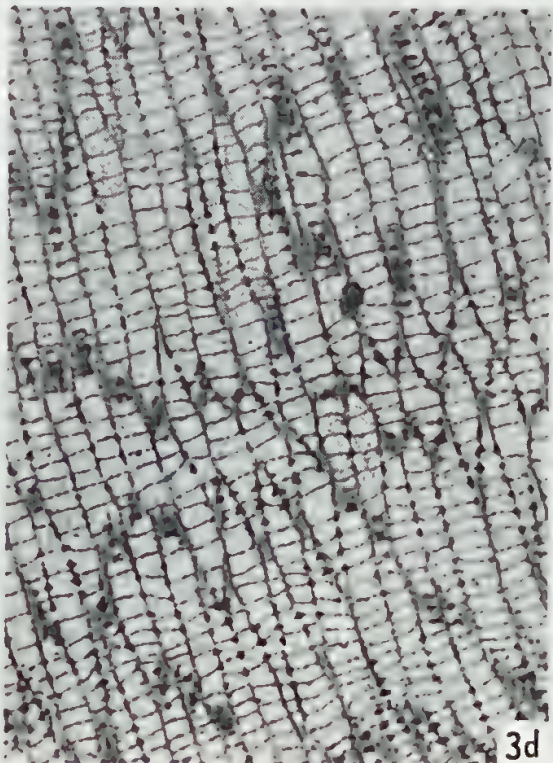
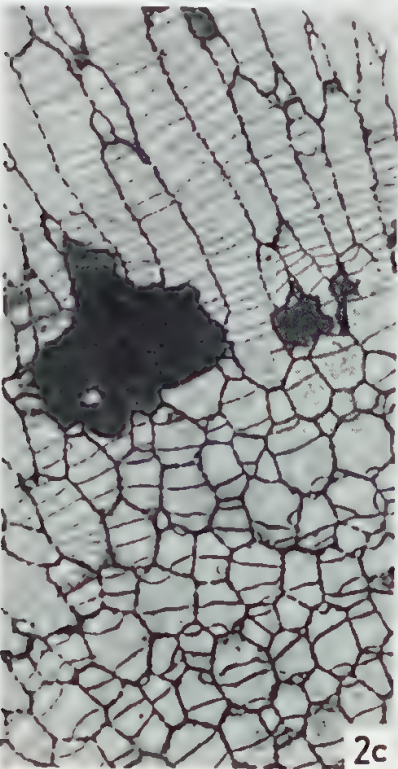
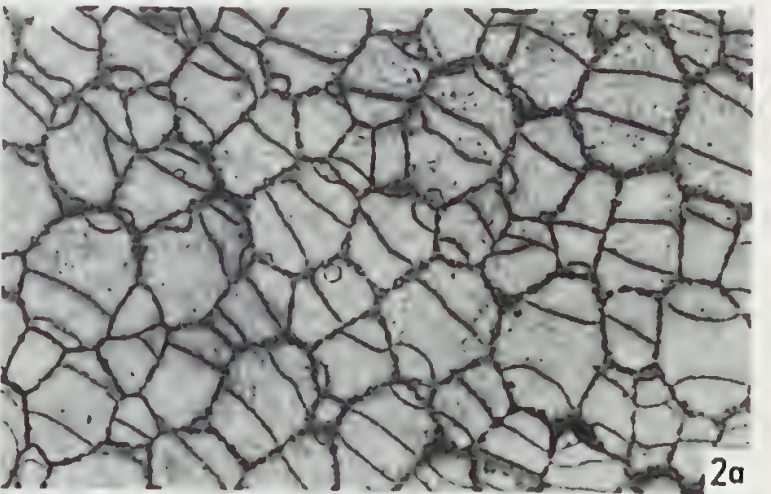
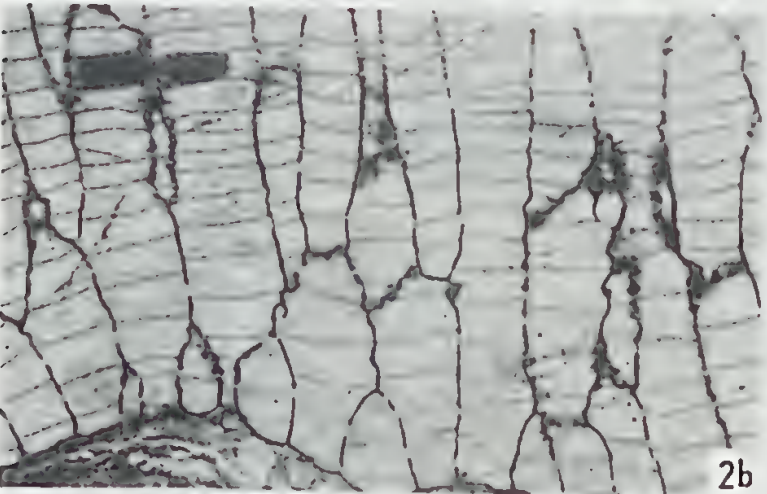
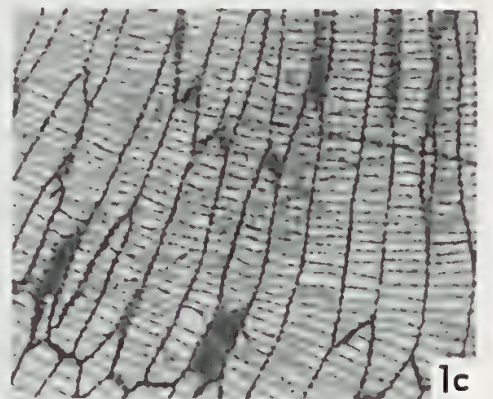
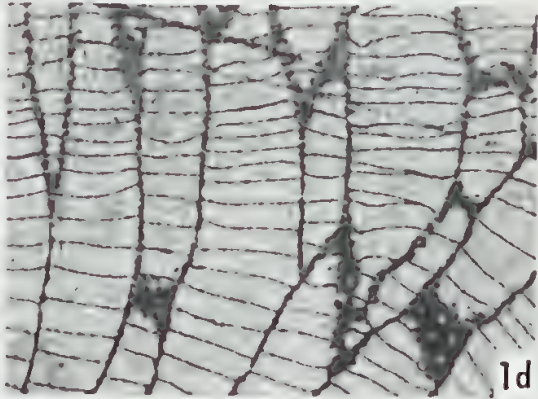
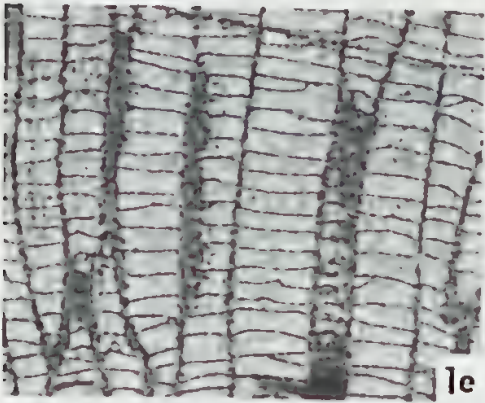
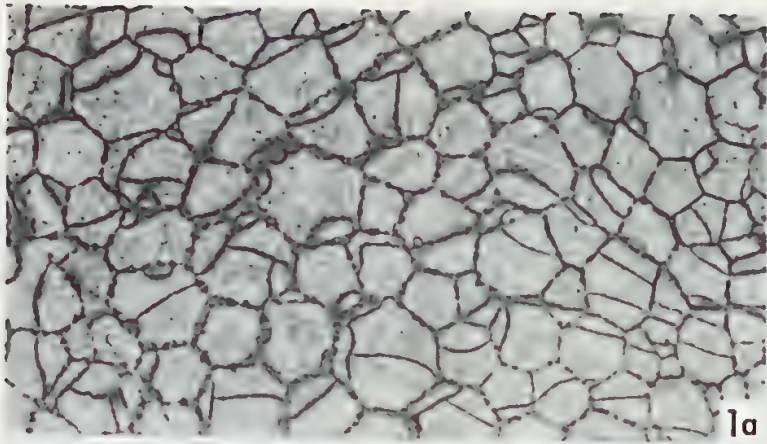


PLATE 6



#### EXPLANATION OF PLATE 7

Fig. 1. *Squameofavosites nitidus* (Chapman). Ukalunda Beds, B76F, in Mary Creek, 'Hidden Valley', 8 miles north-northeast of Mt. Wyatt, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian.

Figure 1—UQF52819; a, b, thin transverse sections, a X2, b X4, c, d, thin longitudinal sections, c X2, d X4.

Fig. 2, 3, *Squameofavosites bryanii* (Jones). 2, Ukalunda Beds, B84F, 2 miles slightly north of west of 'Hidden Valley' homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian. 3, locality as fig. 1.

Figure 2—UQF52832; a, b, thin transverse sections, a X2, b X4, c, d, thin longitudinal sections, c X2, d X4.

Figure 3—UQF52820; a, b, thin transverse sections, a X2, b X4, c, d, thin longitudinal sections, c X2, d X4.



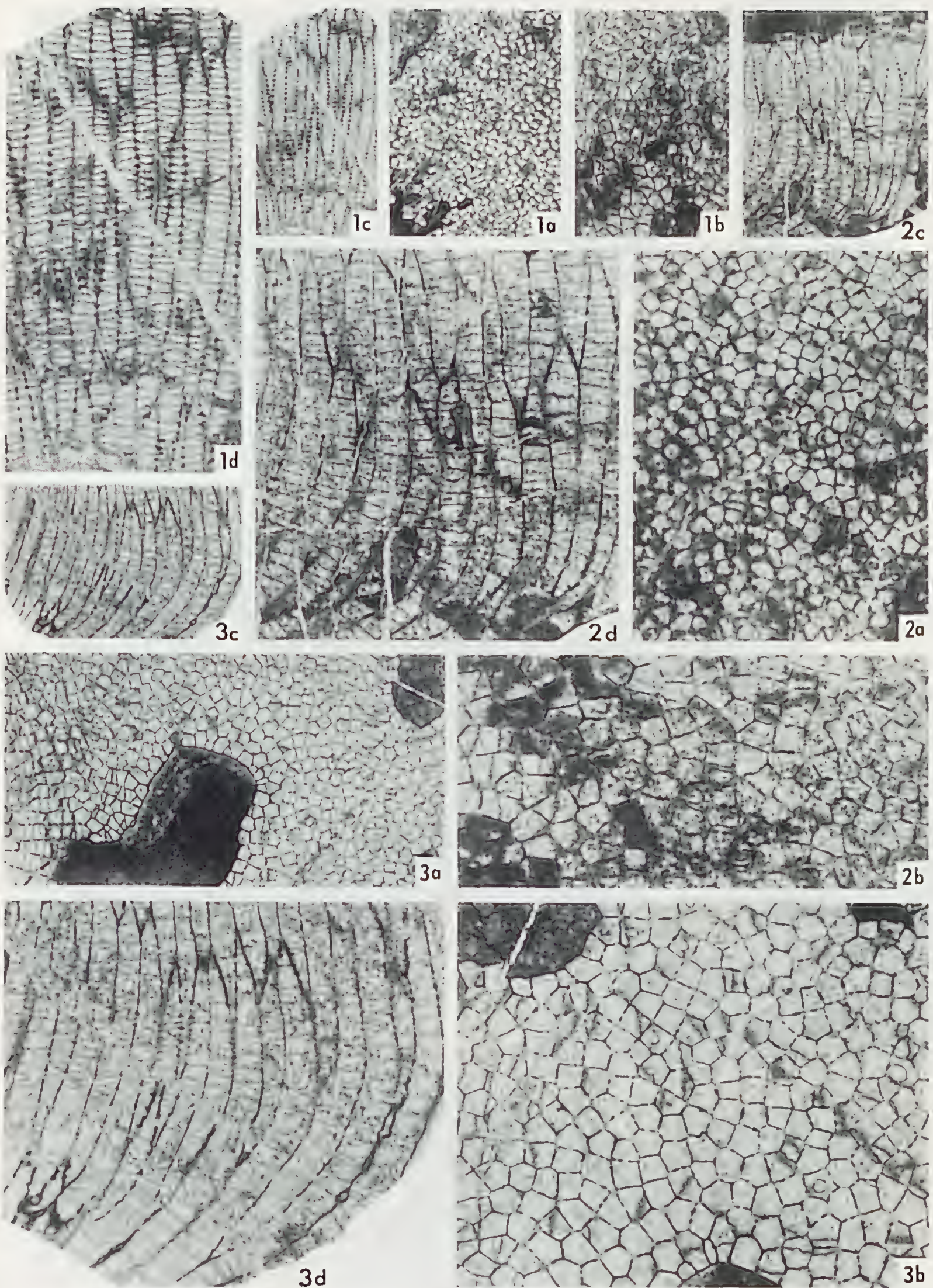


PLATE 7



#### EXPLANATION OF PLATE 8

Figs. 1-6. *Alveolites* sp. cf. *A. stamineus* Hill. 1-3, Ukalunda Beds, B76F, in Mary Creek; 'Hidden Valley', 8 miles north-northeast of Mt. Wyatt, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian. 4, 6, Ukalunda Beds, B84F, 2 miles slightly north of west of Hidden Valley homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian. 5, limestone pebble in the conglomerate at the base of the Drummond Group (*i.e.* probably in the Mt. Wyatt Beds), 2.75 miles west of the Pyramid homestead, Ukalunda district, northwestern part of Bowen 1:250,000 sheet area, north Queensland.

Figure 1—UQF52831; a, oblique thin transverse section, b, thin longitudinal section, X4.

Figure 2—UQF52830; a, oblique thin transverse section, b, thin longitudinal section, X4.

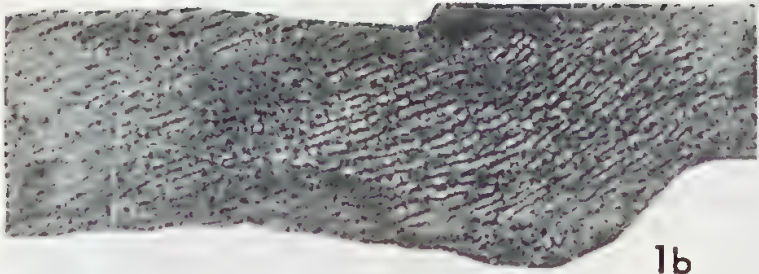
Figure 3—UQF52821, thin longitudinal section, X4.

Figure 4—UQF52833; a, b, thin longitudinal sections, a X2, b X4.

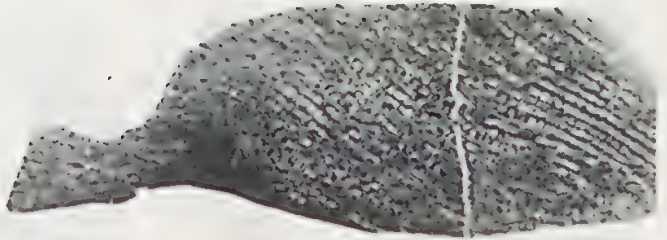
Figure 5—UQF53398; thin longitudinal section, X4.

Figure 6—UQF53401; thin longitudinal section, X4.

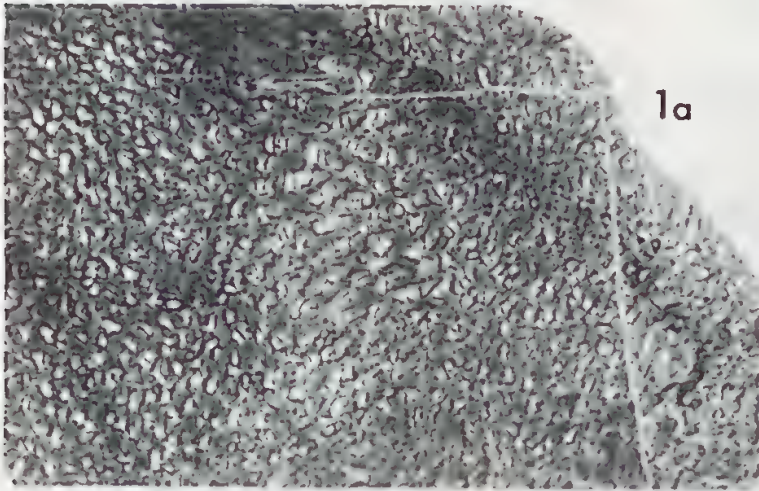




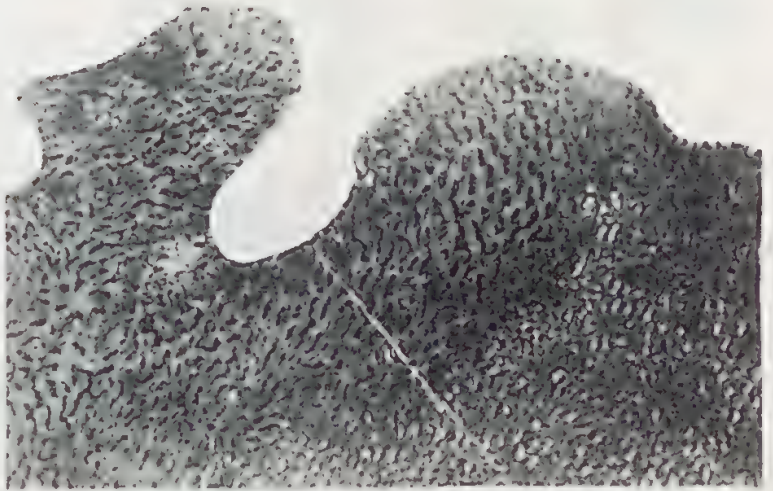
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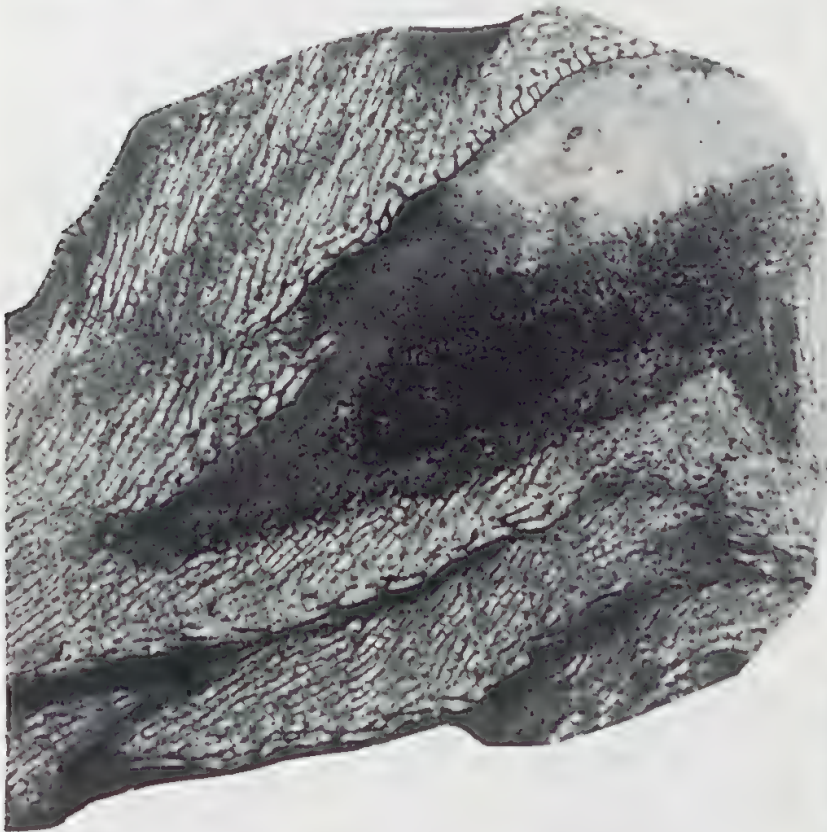
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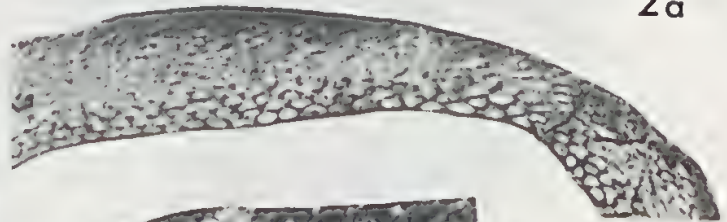
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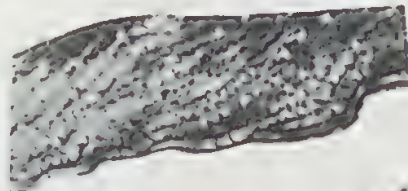
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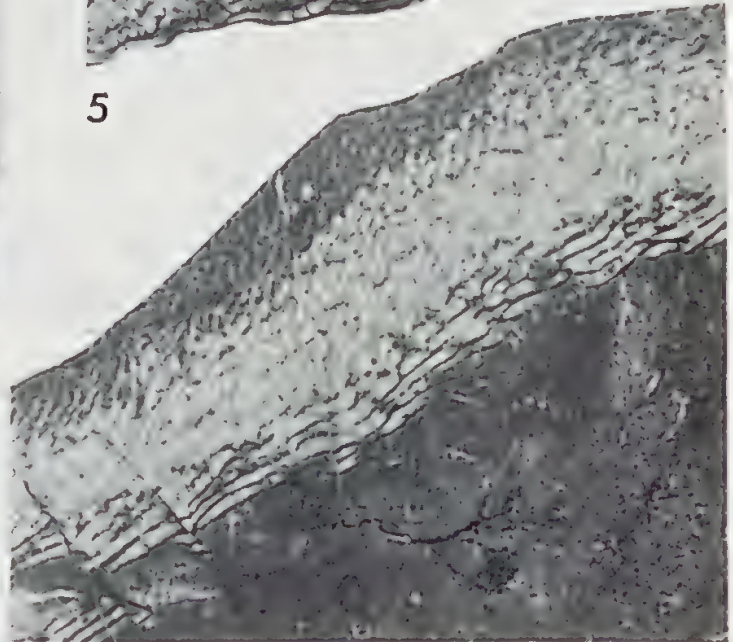
3



4b



5



6



4a



#### EXPLANATION OF PLATE 9

Fig. 1. *Thamnopora?* sp. Ukalunda Beds, B76F, in Mary Creek, 'Hidden Valley', Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian.

Figure 1—UQF52814; a, thin tangential section, b, thin longitudinal section, X4.

Figs. 2-6. *Cladopora* sp. 2, Ukalunda Beds, B84F, 2 miles slightly north of west of Hidden Valley homestead, Ukalunda district, southwestern part of the Bowen 1:250,000 sheet area, north Queensland; probably Couvinian. 3-6, locality as for fig. 1.

Figure 2—UQF52799; thin section, X4.

Figure 3—UQF52805; thin median longitudinal section, X4.

Figure 4—UQF52808; thin transverse section, X4.

Figure 5—UQF52807; thin median longitudinal section, X4.

Figure 6—UQF52801, thin section, X4.

Figs. 7, 8. *Thamnopora?* sp. 7, locality as for fig. 1. 8, Locality as for fig. 2.

Figure 7—UQF52815; a, thin longitudinal section, b, thin tangential section, X4.

Figure 8—UQF52816; a, thin tangential section, b, thin longitudinal section, X4.

Fig. 9. *Aulopora* sp. Locality as for fig. 2.

Figure 9—UQF53349; thin section, X4.

Fig. 10. *Pseudoplasmodora* sp. cf. *P. gippslandica* (Chapman). Locality as for fig. 1.

Figure 10—UQF52829; a, thin transverse section, b, thin longitudinal section, X4.

Fig. 11 *Alveolites* sp. cf. *A. stamineus* Hill. Locality as for fig. 2.

Figure 11—UQF52834, thin section, X4.



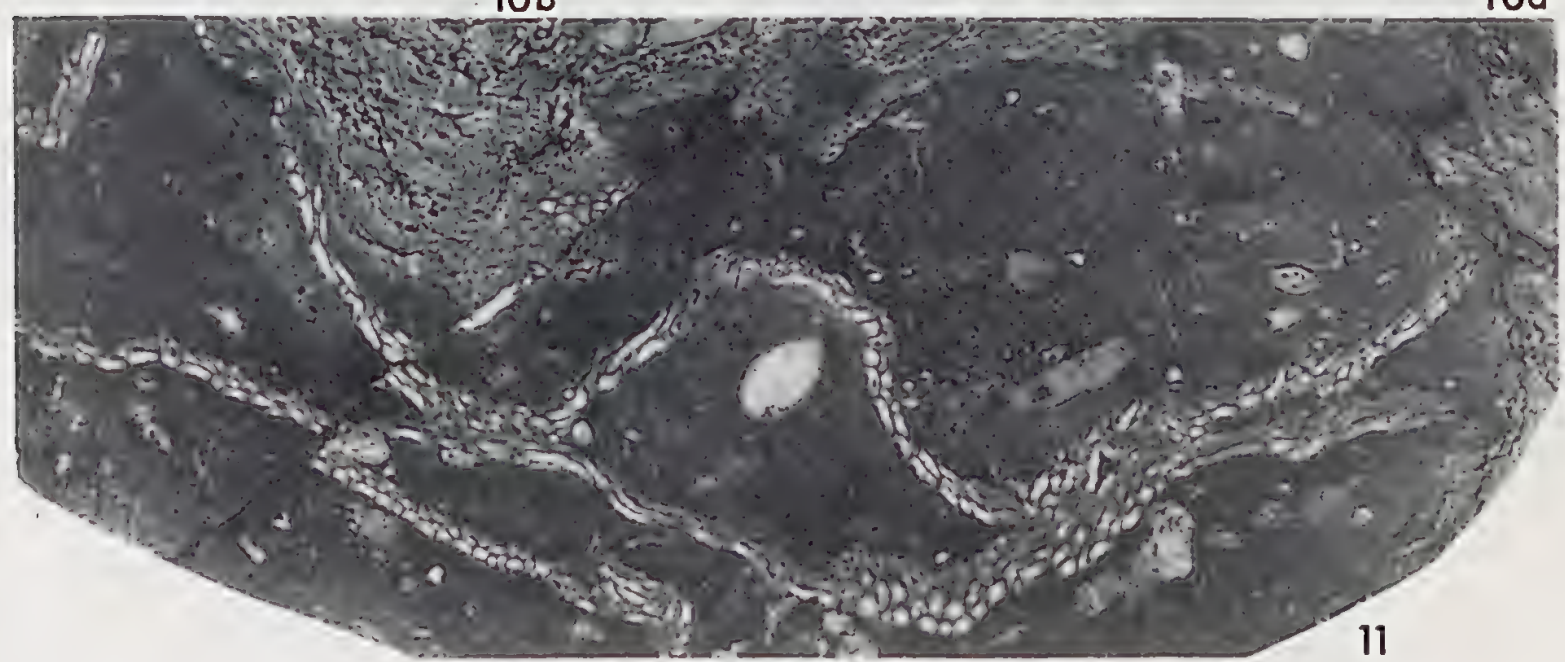
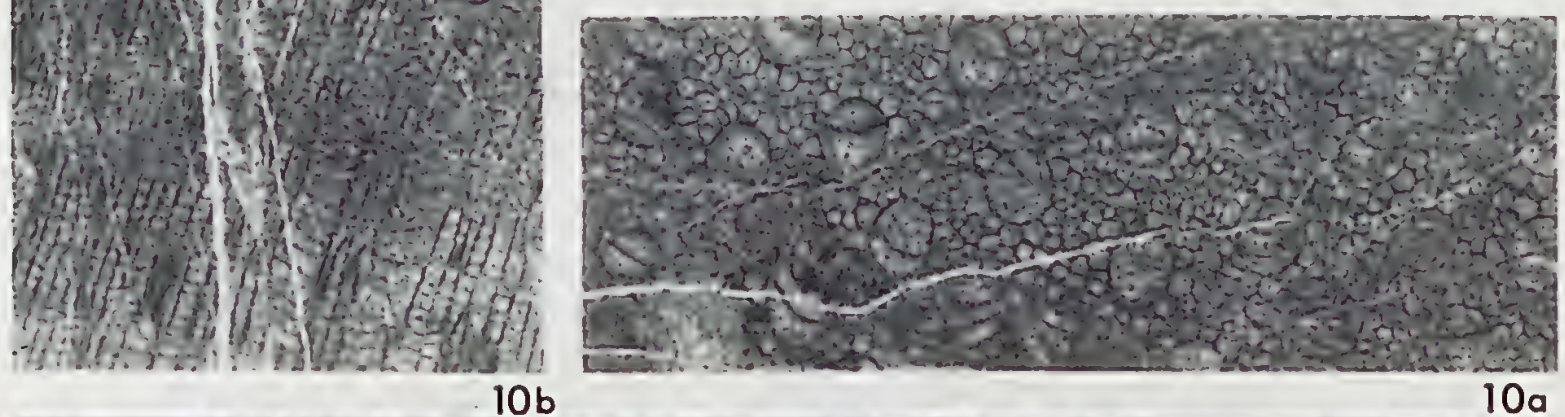
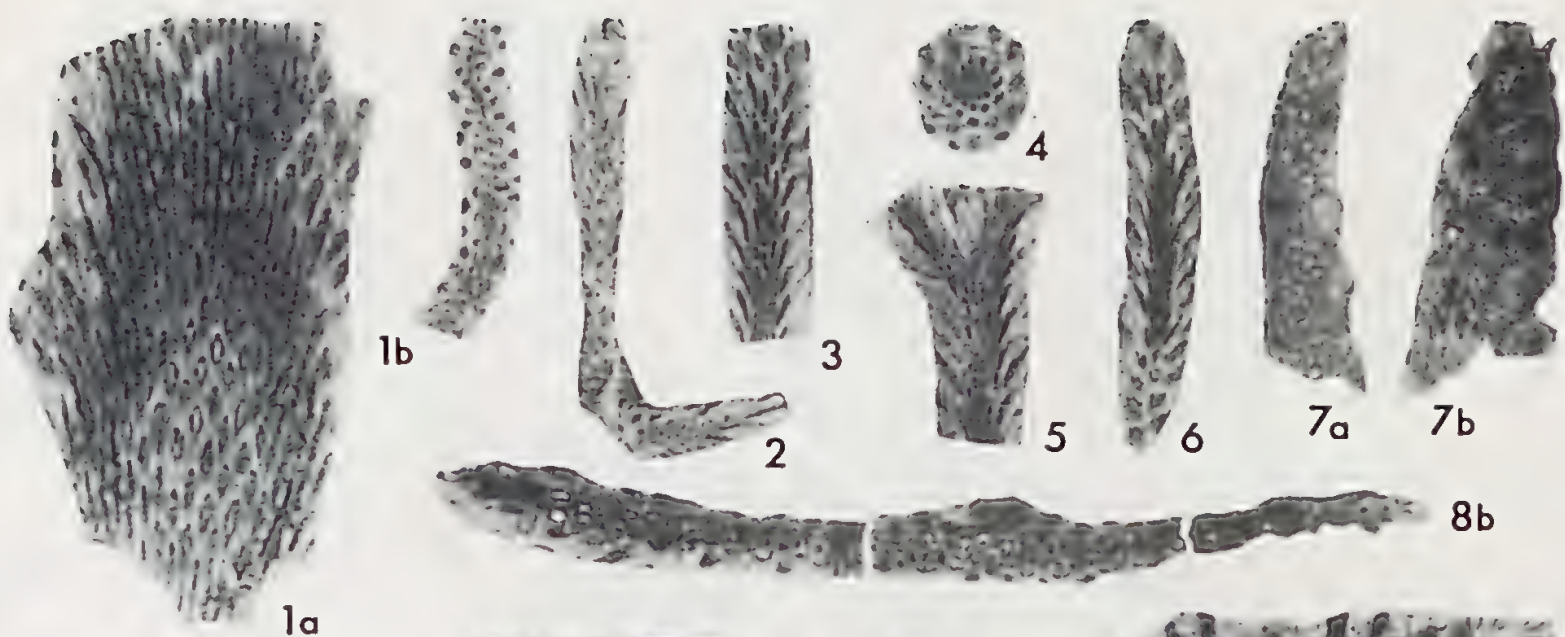


PLATE 9





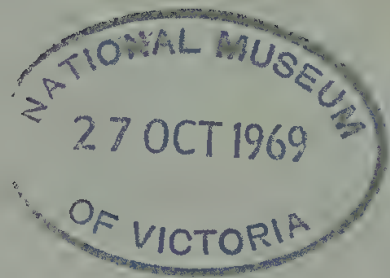












QUEENSLAND  
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GEOLOGICAL SURVEY OF QUEENSLAND  
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FROM LIMESTONES NEAR MURGON,  
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## ABSTRACT

An Upper Carboniferous (Lower Pennsylvanian) conodont fauna, previously recorded as Siluro-Devonian, is described from limestones in close proximity to sediments of the Wondai "Series", south-east of Murgon. Thirty conodont species belonging to eleven genera, including *Gnathodus*, *Idiognathodus*, *Idiognathoides*, and *Streptognathodus*, represent the youngest conodont assemblage so far described from Australia. The Wondai "Series" has been regarded as Lower Palaeozoic in age.

## INTRODUCTION

Conodonts, together with foraminifera and fish and annelid remains, were recovered from insoluble residues from samples of limestones that outcrop in an area about 2 miles long and  $\frac{1}{2}$  mile wide, extending north and south of the confluence of Barambah and Barker Creeks (Text Figure 1), 5 miles south-east of Murgon.

Reid (1925, p. 91) assigned the limestones near Murgon to his Wondai "Series", a sequence of slates, quartzites and jaspers of possible Lower Palaeozoic age. Rocks of the "Series" outcrop along the western margin of the Esk Rift between Murgon and Wondai.

The age of the Wondai "Series" has been uncertain owing to the lack of fossils. However the "Series" was regarded by Hill and Denmead (1960, p. 137) as a structurally isolated part of the Neranleigh-Fernvale Group along the western side of the Esk Rift. Hill (1961, p. 129) reported that the oldest rocks outcropping in the Yarraman Block were considered to be Neranleigh-Fernvale equivalents, and that "no fossils were known in these other than crinoidal detritus in limestones near Wondai".

The limestones are massive and pale grey with rare concentrations of crinoidal remains. Structural irregularities and weathering patterns make it difficult to obtain an average dip, and their thickness is unknown. However, along the eastern side of Barker Creek they form a cliff about 40 feet high and appear to strike north-north-west and dip westward. The relationship of the limestones east of Barker Creek to the altered sediments of the Wondai "Series" to the west has not been established. Sawers (1968) has suggested that the contact may be a faulted one.

About 200 specimens were obtained from a total of 150 pounds of limestones processed in 10 percent acetic acid solution. One of the twelve samples collected yielded more than half the entire fauna (110 specimens, 133 outcrop E) and four other samples (37, 124A, 125, 131) an average of 20 conodonts (Table 1).

Conodonts were first discovered from Murgon in a limestone sample collected by Mr. J. D. Sawers of the Geological Survey of Queensland in 1966, and tentatively identified as being of Silurian-Devonian age (Palmieri, 1967). The further collections described in this paper were made by the author and proved to contain forms indicating an Upper Carboniferous age.

Fish, annelid and foraminiferal remains were also retrieved from the residues after bromoform separation, and have been tentatively identified at generic level.

TABLE 1

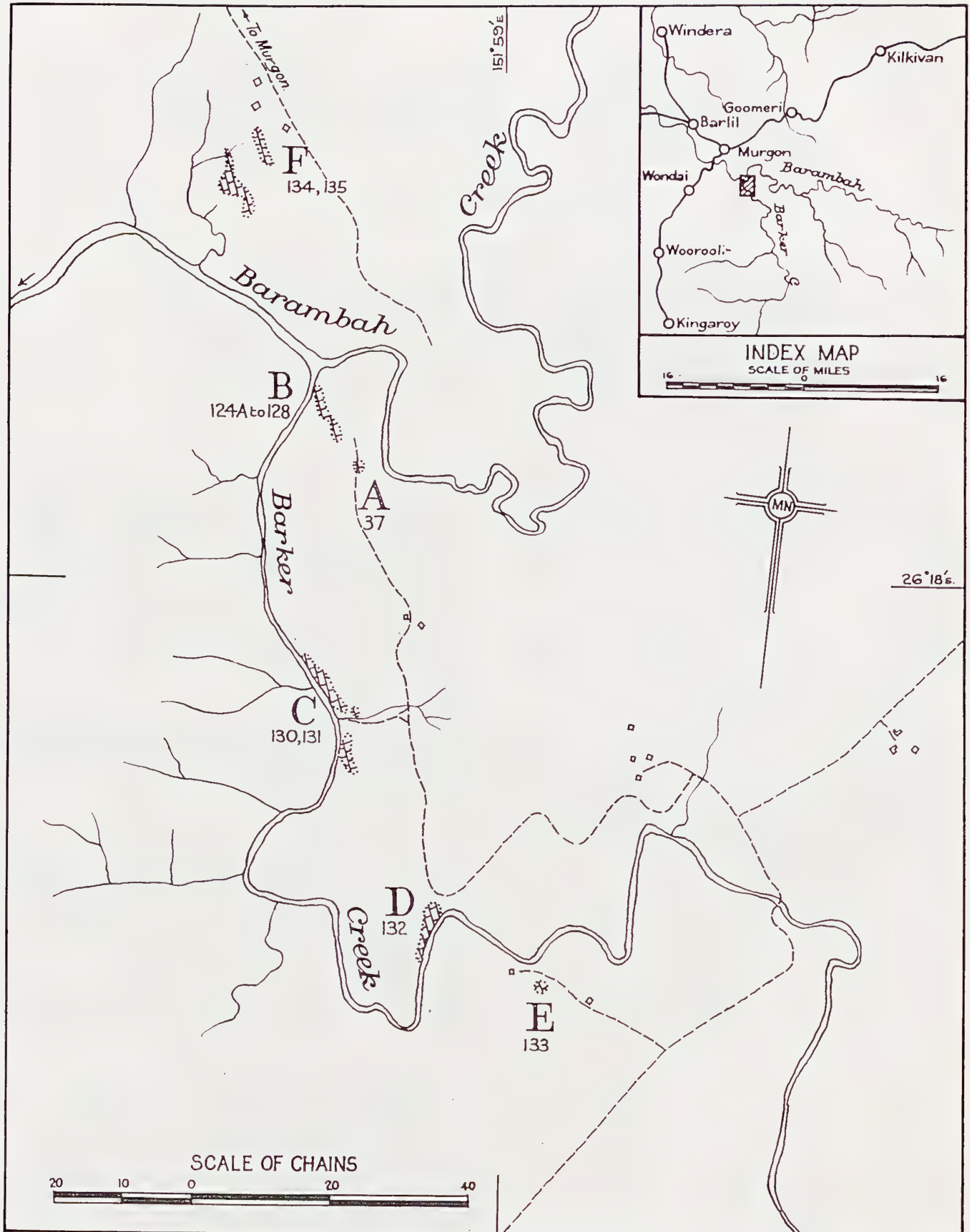
Quantitative distribution of conodonts and other organisms  
(foraminifera, annelid and fish remains)

| Sample No. | Outcrop | Quantity Processed (lbs) | No. of conodonts | No. of other organisms |
|------------|---------|--------------------------|------------------|------------------------|
| 37         | A       | 10                       | 15               | 10                     |
| 124A       | B       | 20                       | 25               | 35                     |
| 124        | B       | 20                       | 3                | 30                     |
| 125        | B       | 20                       | 30               | 20                     |
| 126        | B       | 5                        | —                | —                      |
| 127        | B       | 5                        | 1                | 3                      |
| 128        | B       | 5                        | —                | —                      |
| 130        | C       | 20                       | 7                | 8                      |
| 131        | C       | 20                       | 12               | —                      |
| 132        | D       | 5                        | —                | —                      |
| 133        | E       | 20                       | 110              | 45                     |
| 134        | F       | 5                        | —                | —                      |
| 135        | F       | 5                        | 1                | —                      |

## PREVIOUS UPPER CARBONIFEROUS CONODONT RESEARCH AND ZONATION

In North America Upper Carboniferous (Pennsylvanian) conodonts were first mentioned in 1915 by Girty from shales from Missouri and Kansas. Following this, Upper Carboniferous conodont assemblages were studied from the Fort Scott Limestone, Missouri (Gunnell, 1931); the Cherokee and Wabaunsee Groups, Missouri and Kansas (Gunnell, 1931); various shales, Texas (Stauffer





Text Figure 1. Outcrops of the Murgon limestones.



and Plummer, 1932); the Cromwell Member of the Wapanucka Formation, the Pawhuska Formation and the Boggy Formation, Oklahoma (Harris and Hollingsworth, 1933); and the Johns Valley Shale, Oklahoma (Harlton, 1933). The new platform conodont genera *Idiognathodus* Gunnell, *Gondolella* Stauffer and Plummer, *Cavusgnathus* Harris and Hollingsworth, *Idiognathoides* Harris and Hollingsworth, and *Polygnathodella* Harlton were described. However no conodont zonation was attempted at this stage.

Pennsylvanian conodont assemblages have also been described from the Dimple Limestone of the Marathon region, Texas (Ellison and Graves, 1941); shales near Knoxville, Iowa (Youngquist and Heezen, 1948; Youngquist and Downs, 1949); and the Hamden Limestone and Washingtonville Shale of the Allegheny Formation, eastern Ohio (Sturgeon and Youngquist, 1949). Rhodes (1952) described some new conodont assemblages from the Pennsylvanian of Illinois and Kentucky in an attempt to build up a natural classification.

Conodonts of Lower Pennsylvanian age were described by McLaughlin (1952) from the Glen Eyrie Formation, Colorado. Others, of Desmoinesian age, were described by Murray and Chronic (1965) from the Minturn Formation, Colorado. Clarke (1960) described an assemblage from the Millstone Grit and the Skipsey's Marine Band of the Namurian and Westphalian of Scotland. Lys, Mauvier, and Serre (1962) recorded and listed conodonts from the Namurian of northern France. In Japan, Igo and Koike (1964, 1965) recorded two conodont faunas, one from the Omi Limestone, Nishikubiki County, Niigata Prefecture, and the other from the Akiyoshi Limestone at the Uzura quarry, Yobara, Ofuku, Yamaguchi Prefecture. Both indicate an early Pennsylvanian age.

Dunn (1966) recorded and described several new early Pennsylvanian platform conodonts from exposures in Muskogee, Cherokee, Sequoyah and Atokan Counties, Oklahoma, in Hudspeth County, Texas, and in the Bird Spring Formation, Clark County, Nevada.

The first tentative zonation in the Upper Carboniferous was attempted by Lane (1967) in his study on platform conodonts from the type Morrowan section, Arkansas. The following zones have been ascertained for the uppermost Mississippian and early Pennsylvanian (Morrowan), in descending order:

|   |                 |                                                       |
|---|-----------------|-------------------------------------------------------|
| P | Middle Morrowan | <i>Idiognathodus</i> sp. Zone                         |
| E |                 |                                                       |
| N | —————           | <i>Gnathodus bassleri bassleri</i> Zone               |
| N |                 |                                                       |
| S |                 | Barren interval                                       |
| Y |                 |                                                       |
| L |                 | Impoverished interval                                 |
| V |                 |                                                       |
| A | Lower Morrowan  | <i>Gnathodus bassleri symmetricus</i> Zone            |
| N |                 |                                                       |
| I |                 | <i>Idiognathoides</i> aff. <i>I. noduliferus</i> Zone |
| A |                 |                                                       |
| N |                 | Interval with no conodonts                            |
|   |                 | —————                                                 |
|   |                 | <i>Adetognathus unicornis</i> Zone                    |

MISSISSIPPIAN  
(Uppermost Chesterian)

## THE AGE OF THE MURGON FAUNA

The fauna is characterized by an association of species belonging to the genera *Gnathodus*, *Idiognathodus*, *Idiognathoides*, and *Streptognathodus*, which indicate an Upper Carboniferous (Pennsylvanian) age.

It is comparable with Pennsylvanian associations, mainly from North America, described by Harris and Hollingsworth (1933), Harlton (1933), Ellison and Graves (1941), McLaughlin (1952), Murray and Chronic (1965), Dunn (1966) and Lane (1967). Similar conodont associations were also found in the Namurian and Westphalian in Scotland (Clarke, 1960), the Namurian of northern France (Lys, Mauvier, and Serré, 1962), and in early Pennsylvanian limestones in Japan (Igo and Koike, 1964, 1965).

*Gnathodus* is represented mostly by species lacking ornamentation on the cup. According to Lindström (1964, pp. 55, 56) this is an evolutionary development in the genus *Gnathodus* that appears in the upper part of the Lower Carboniferous (Mississippian). However it also occurs in the lower part of the Lower Carboniferous (Druce, *pers. comm.*). It is seen in *G. commutatus* (Branson and Mehl) and related species. With one exception all the Murgon species seem to belong to the group lacking cup ornamentation. Among them, *G. sp. A* (37, 124A, 125, 133) resembles *G. scotiaensis* Globensky, 1967, from the Middle and Upper Mississippian of the Windsor Group, Canada. *G. sp. A* also has similarities with *G. commutatus* (Branson and Mehl) from the lower Namurian of north Staffordshire, England, and the Griotte Limestone, Spain (Higgins, 1961, 1962). *G. sp. B* (37) appears to be related to *G. opimus* Igo and Koike, 1964, from the early Pennsylvanian of Japan, and to *G. commutatus homopunctatus* Bischoff, 1957, as interpreted by Higgins (1961) from the lower Namurian of north Staffordshire, England.

*G. sp. C* (37, 124A, 125, 133) strongly resembles *G. commutatus nagatoensis* Igo and Koike, 1965, an extremely variable subspecies, from the Akiyoshi Limestone, early Pennsylvanian, Japan.

*Idiognathoides* Harris and Hollingsworth is a relatively common platform conodont genus in the Murgon fauna. It is represented by the species *I. aff. I. noduliferus* (Ellison and Graves) (37, 124A, 125, 131, 133), *I. cf. I. sinuatus* Harris and Hollingsworth (131, 133, 125), *I. attenuatus* (Harris and Hollingsworth) (131), and *I. tenuis* (Clarke) (130). *I. noduliferus* (Ellison and Graves) is known from the Dimple Limestone of the Marathon region, early Pennsylvanian, Texas (Ellison and Graves, 1941); the Millstone Grit of the Midland Valley, Namurian-Westphalian, Scotland (Clarke, 1960); the Griotte Limestone, Namurian, north-west Spain (Higgins, 1962); the Omi Limestone, early Pennsylvanian, central Japan (Igo and Koike, 1964); and the Prairie Grove Member of the Hale Formation, Morrowan, Arkansas (Lane, 1967). *I. sinuatus* Harris and Hollingsworth has been found in the Cromwell Member of the Wapanucka Formation, early Pennsylvanian, Oklahoma (Harris and Hollingsworth, 1933); the Dimple Limestone of the Marathon region, early Pennsylvanian, Texas (Ellison and Graves, 1941); the Omi Limestone, early Pennsylvanian, central Japan (Igo and Koike, 1964); and the Prairie Grove Member of the Hale Formation, as well as



the Brentwood Member of the Bloyd Formation, Morrowan, Arkansas (Lane, 1967). *I. attenuatus* (Harris and Hollingsworth) was described from the Cromwell Member of the Wapanucka Formation, early Pennsylvanian, Oklahoma (Harris and Hollingsworth, 1933). *I. corrugatus* (Harris and Hollingsworth) is known from the Cromwell Member of the Wapanucka Formation, early Pennsylvanian, Texas (Ellison and Graves, 1941), and the Brentwood Member of the Bloyd Formation, Morrowan, Arkansas (Lane, 1967). *I. tenuis* (Clarke) was recorded and described from the Skipsey's Marine Band, Westphalian, Scotland (Clarke, 1960).

*Idiognathoides* consequently is an excellent guide fossil for intercontinental correlation in the Upper Carboniferous.

Three specimens referable to *Idiognathodus* Gunnell were obtained. Among them, *I. cf. I. delicatus* Gunnell (125) closely resembles the species recorded from the Dimple Limestone of the Marathon region, Texas (Ellison and Graves, 1941); *I. sp.* (124A) resembles to some extent *I. meekerensis* Murray and Chronic from the Minturn Formation, Desmoinesian, Colorado (Murray and Chronic, 1965); and a third fragmentary and badly preserved specimen shows similarities with *I. sp.* from the Hamden Limestone and the Washingtonville Shale of the Allegheny Formation, Desmoinesian, eastern Ohio (Sturgeon and Youngquist, 1949).

Conodonts of the genus *Streptognathodus* Stauffer and Plummer were obtained from samples 124A, 125 and 131. *S. angustus* Dunn (124A, 125) and *S. suberectus* Dunn (125) are known from the Morrowan of the Bird Spring

Formation, Clark County, Nevada (Dunn, 1966); and *S. elegantulus* Stauffer and Plummer (131) occurs in the Desmoinesian, Missourian and Virgilian Series, Missouri and Kansas (Ellison, 1941), and in the Pawhuska Formation, Lower Pennsylvanian, Oklahoma (Harris and Hollingsworth, 1933).

Among the other conodont species retrieved from the limestones, *Spathognathodus minutus* (Ellison) (124A, 125) is known from the Desmoinesian, Missourian and Virgilian Series, Kansas and Missouri (Ellison, 1941); the Hamden Limestone and the Washingtonville Shale of the Allegheny Formation, Desmoinesian, eastern Ohio (Sturgeon and Youngquist, 1949); the Minturn Formation, Desmoinesian, Colorado (Murray and Chronic, 1965); the Akiyoshi Limestone, early Pennsylvanian, Japan (Igo and Koike, 1965); and the Kinkaid Limestone, uppermost Chesterian, Illinois (Rexroad and Burton, 1961), which is considered to be the lowermost occurrence of the species. *Spathognathodus spiculus* Youngquist and Miller (37, 133) occurs in the Sweetland Creek and Pella Formations, Iowa, Upper Mississippian (Youngquist and Miller, 1949; Rexroad and Furnish, 1964), and the Windsor Group, Middle-Upper Mississippian, Canada (Globensky, 1967). *Synprioniodina microdenta* Ellison (124A, 125, 133) has been reported from the Desmoinesian and Missourian Series, Kansas and Missouri (Ellison, 1941); the Dimple Limestone, Marathon region, early Pennsylvanian, Texas (Ellison and Graves, 1941); and the Minturn Formation, Desmoinesian, Colorado (Murray and Chronic, 1965). *Hindeodus imperfectus* (Rexroad) (125, 133) is known from the Chesterian Series of Illinois and Indiana (Rexroad and Burton,

TABLE 2  
Distribution of conodonts in the outcrops near Murgon

| Conodonts                                                      | Outcrop A<br>37 | 124A | Outcrop B<br>124 | 125 | 127 | Outcrop C<br>130 | 131 | Outcrop E<br>133 | Outcrop F<br>135 |
|----------------------------------------------------------------|-----------------|------|------------------|-----|-----|------------------|-----|------------------|------------------|
| <i>Gnathodus cf. G. bassleri</i> (Harris and Hollingsworth)    |                 |      |                  |     |     |                  |     | x                |                  |
| <i>Gnathodus sp. A</i> .. .. .                                 | x               | x    |                  | x   |     |                  |     | x                |                  |
| <i>Gnathodus sp. B</i> .. .. .                                 | x               |      |                  |     |     |                  |     | x                |                  |
| <i>Gnathodus sp. C</i> .. .. .                                 | x               | x    |                  | x   |     | x                |     | x                |                  |
| <i>Hindeodella spp.</i> .. .. .                                | x               | x    | x                | x   |     | x                | x   | x                |                  |
| <i>Hindeodus imperfectus</i> (Rexroad) .. .. .                 |                 |      |                  | x   |     |                  |     | x                |                  |
| <i>Hindeodus spp.</i> .. .. .                                  |                 |      | x                | x   |     |                  |     | x                |                  |
| <i>Idiognathodus cf. I. delicatus</i> Gunnell .. .. .          |                 |      |                  | x   |     |                  |     |                  |                  |
| <i>Idiognathodus spp.</i> .. .. .                              |                 | x    | x                | x   |     |                  |     |                  |                  |
| <i>Idiognathoides attenuatus</i> (Harris and Hollingsworth)    |                 |      |                  |     |     |                  |     | x                |                  |
| <i>Idiognathoides corrugatus</i> (Harris and Hollingsworth)    |                 |      |                  |     |     |                  |     | x                |                  |
| <i>Idiognathoides aff. I. noduliferus</i> (Ellison and Graves) | x               | x    |                  | x   |     |                  | x   | x                |                  |
| <i>Idiognathoides cf. I. sinuatus</i> Harris & Hollingsworth   |                 |      |                  | x   |     |                  | x   | x                |                  |
| <i>Idiognathoides cf. I. tenuis</i> (Clarke) .. .. .           |                 |      |                  |     |     | x                |     |                  |                  |
| <i>Idiognathoides (?) sp.</i> .. .. .                          |                 |      |                  |     |     |                  | x   | x                |                  |
| <i>Ligonodina spp.</i> .. .. .                                 | x               | x    | x                | x   |     |                  |     | x                |                  |
| <i>Lonchodina sp.</i> .. .. .                                  | x               |      |                  |     |     |                  |     | x                |                  |
| <i>Ozarkodina delicatula</i> (Stauffer and Plummer)            |                 |      |                  |     |     |                  | x   | x                |                  |
| <i>Ozarkodina spp.</i> .. .. .                                 |                 | x    | x                |     |     | x                |     | x                |                  |
| <i>Spathognathodus minutus</i> (Ellison) .. .. .               |                 | x    |                  | x   |     |                  |     |                  |                  |
| <i>Spathognathodus spiculus</i> Youngquist and Miller          | x               |      |                  |     |     |                  |     | x                |                  |
| <i>Spathognathodus spp.</i> .. .. .                            |                 |      | x                |     |     |                  |     | x                |                  |
| <i>Spathognathodus (?) sp.</i> .. .. .                         | x               |      |                  |     |     |                  |     |                  |                  |
| <i>Streptognathodus angustus</i> Dunn .. .. .                  |                 | x    |                  | x   |     |                  |     |                  |                  |
| <i>Streptognathodus elegantulus</i> Stauffer and Plummer       |                 |      |                  |     |     |                  | x   |                  |                  |
| <i>Streptognathodus aff. S. suberectus</i> Dunn .. .. .        |                 |      |                  | x   |     |                  |     |                  |                  |
| <i>Streptognathodus sp.</i> .. .. .                            |                 |      |                  | x   |     |                  |     |                  |                  |
| <i>Synprioniodina microdenta</i> Ellison .. .. .               |                 | x    |                  | x   |     |                  |     | x                |                  |
| ? <i>Gondolella</i> spp. indetermin. fragments .. .. .         |                 |      |                  |     | x   |                  |     |                  | x                |



1961; Rexroad and Collinson, 1963). *Ozarkodina delicatula* (Stauffer and Plummer) (131, 133) has been reported from the Glen Dean Formation to the Kinkaid Limestone of the Chesterian Series, Illinois (Rexroad and Burton, 1961), and from the Desmoinesian, Missourian and Virgilian Series, Missouri and Kansas (Ellison, 1941).

Two small conodont fragments, possibly belonging to the genus *Gondolella* Stauffer and Plummer, were obtained from samples 127 and 135.

The study of the conodonts from the limestones near Murgon leads to the following conclusions:

(a) The entire fauna comprises both Upper Mississippian (Chesterian) and Pennsylvanian species.

(b) The presence of *Idiognathoides corrugatus* (Harris and Hollingsworth) (131, 133), *I. sinuatus* Harris and Hollingsworth (131, 133), *I. tenuis* (Clarke) (130), *I. attenuatus* (Harris and Hollingsworth) (133), and *I. aff. I. noduliferus* (Ellison and Graves) (37, 124A, 125, 131, 133) suggests a Lower Pennsylvanian age (Morrowan-Atokan).

(c) Samples 37 and 133 may be slightly older than the others, because of the absence of the genera *Streptognathodus* and *Idiognathodus* (which are not known from the earliest Pennsylvanian), and the presence of probable late Mississippian species of *Gnathodus* and *Spathognathodus*.

(d) The presence of the genus *Idiognathodus* alone or in association with *Streptognathodus*, in addition to the species *Spathognathodus minutus* (Ellison) and *Synprioniodina microdonta* Ellison, would seem to indicate a rather later Lower Pennsylvanian age for samples 124A and 125.

(e) Although the conodont fauna under consideration needs further study to establish the precise range and distribution of species and genera, the evidence points to an early Pennsylvanian age for most of the Murgon limestones, though some of the strata may be as old as late Mississippian (Chesterian) or as young as lower Middle Pennsylvanian (Desmoinesian).

## SYSTEMATIC PALAEONTOLOGY

### Genus GNATHODUS Pander, 1856

*Type species: Gnathodus mosquensis* Pander, 1856; Carboniferous, Bergkalk, Moscow, Russia.

*Gnathodus* cf. *G. bassleri* (Harris and Hollingsworth)  
Pl. 4, figs. 27, 28

cf. *Gnathodus bassleri* (Harris and Hollingsworth, 1933).  
Lane, 1967, *J. Paleont.*, 41 (4), pp. 934-936, pl. 120, figs. 1-5, 9-15, 17; pl. 121, figs. 6, 9; pl. 123, figs. 1-6.

*Material:* 1 specimen (Outcrop E, 133).

*Figured specimen:* GSQ MF 004.

*Description:* A specimen of *Gnathodus* showing on the platform two parapetlike margins, anteriorly and centrally subparallel, and posteriorly converging to the carina.

The central carina consists of a row of nodes. A series of transverse ridges symmetrically joins the nodes of the parapets with the nodes of the carina. The blade bears anteriorly distinct denticles, becoming coalesced before the attachment of the blade with the carina. The basal cavity is located in the posterior half of the unit and terminates in a sharp point, giving a symmetrical lanceolate outline to the specimen.

*Remarks:* Despite its small size and its slightly deformed outer side, this specimen resembles *G. bassleri symmetricus* Lane in having a deep gnathodid-type basal cavity, a central carina between the platform margins, the characteristic transverse ridges or nodes converging to the carina from the parapets, and a symmetrical lanceolate shape in oral view. However, in lateral view the inner side is slightly arched and elevated above the carina so that the general shape is not as straight as in the specimens figured by Lane (1967).

*Gnathodus* cf. *G. bassleri* differs from species of *Streptognathodus* in possessing a carina extending to the posterior tip.

*Gnathodus bassleri symmetricus* and *G. bassleri bassleri* are two zonal subspecies in Lane's conodont zonation of the early Pennsylvanian of Arkansas. Their initial appearance is in the middle part of the Prairie Grove Member of the Hale Formation (middle lower Morrowan), and they range up into the middle part of the Brentwood Member of the Bloyd Formation (late lower Morrowan).

### *Gnathodus* sp. A

Pl. 1, figs. 12, 18-19, 22-24; pl. 2, figs.  
21-24, 27, 28; pl. 3, figs. 6, 21, 27

*Material:* 12 specimens (outcrop A, 37; outcrop B, 124A, 125; outcrop E, 133).

*Figured specimens:* GSQ MF 003/1-003/9.

*Description:* Axis anteriorly straight, posteriorly bowed. Basal cavity elongated, deep, occupying the posterior half of the unit. Blade bearing anteriorly distinct denticles, centrally coalesced, continuing posteriorly as carina with nodelike or transversely expanded denticles. No ornamentation on the cup.

*Remarks:* The specimens grouped under *Gnathodus* sp. A appear to be related to the species *Gnathodus scotiaensis* Globensky, recovered from the Middle and Upper Mississippian of the Windsor Group, eastern Canada (Globensky, 1967, p. 441, pl. 58, figs. 2-7, 10, 12). This species was considered by its author to differ from *G. commutatus* (Branson and Mehl) and its various subspecies by the greater size of the basal cavity, elongated rather than almost circular, and by lacking ornament on the cup. Higgins (1961, p. 212) stated that the specific characters of *G. commutatus* (Branson and Mehl) are (a) approximately symmetrical shape in oral view, (b) posteriorly convex cup, (c) anterior median blade continuing posteriorly as a carina; whereas ornamentation, size and shape of the cup, and fusion, number and shape of denticles and nodes, should be considered as having infraspecific value.

Originally *Gnathodus commutatus* was described (Branson and Mehl, 1941, p. 98) as an anteriorly straight



unit slightly downcurved posteriorly, with blade longer than the carina, basal cavity longer than wide and close to the posterior end, and no ornamentation on the cup. Later Higgins (1961, p. 212), redescribing the Bischoff subspecies *Gnathodus commutatus commutatus* on the basis of 181 recovered specimens, included some showing a strongly folded cup, almost circular to oval in shape.

Although some relationship could be seen between *Gnathodus* sp. A, *G. scotiaensis* and *G. commutatus* s.l., the small number of specimens recovered from the Murgon limestones and their poor preservation do not permit specific identification. However the association of *Gnathodus* sp. A in the Murgon fauna with *Idiognathoides* indicates that the range of this group of *Gnathodus* extends into the Lower Pennsylvanian.

*Gnathodus* sp. B

Pl. 1, figs. 1-2

*Material:* 3 specimens (outcrop A, 37; outcrop E, 133).

*Figured specimen:* GSQ MF 001.

*Description:* A unit that has on the inner side of the platform a parapetlike row of nodes anteriorly parallel and posteriorly fused to the carina. The shallow, narrow furrow separating the carina from the parapet disappears towards the posterior tip. Platform oval in shape and posteriorly convex. Inner side of the platform more expanded and restricted in its length than the outer. Anterior blade with 7-8 main denticles becoming coalesced just before the attachment to the carina. The carina consists of 6-7 nodelike denticles increasing slightly in size towards the posterior end.

*Remarks:* Although such features as the oval slightly folded cup, the anteriorly straight blade, and the parapetlike row of nodes on the platform make *Gnathodus* sp. B close to *Gnathodus commutatus homopunctatus* Bischoff (Higgins, 1961, p. 221, pl. 10, fig. 9) and to *Gnathodus opimus* Igo and Koike (1965, p. 89, pl. 9, figs. 1-3), the lack of ornamentation such as nodes or lines of nodes on the sides of the cup distinguishes the Murgon material. However too few specimens were recovered to further the identification.

*Gnathodus* sp. C

Pl. 1, figs. 3-11, 13-17, 20-21; pl. 2, figs. 1-3, 10-18; pl. 3, figs. 13-15

*Material:* 15 specimens (outcrop A, 37; outcrop B, 124A, 125; outcrop C, 130; outcrop E, 133).

*Figured specimens:* GSQ MF 002/1-002/14.

*Description:* A very variable species with axis nearly straight to curved inward, cup almost symmetrical or slightly wider on the outer side, denticles of the carina nodelike to chevronlike; the profile is arcuate or nearly straight, sloping toward the posterior extremity. Blade normally shorter than the platform, thin to slightly convex, with sharp-edged denticles increasing in size near the anterior tip. Oral surface smooth, aboral cavity widest under the attachment scar.

*Remarks:* The specimens grouped under *Gnathodus* sp. C appear to be related to *Gnathodus commutatus nagatoensis* Igo and Koike (1965, p. 89, pl. 9, figs. 9-13) in

having arcuate profile, blade with partially fused denticles, slightly asymmetrical basal cavity, and nodelike carina. However, the lack of ornamentation on the cup and the much broader carina distinguish the Murgon specimens from the types of the subspecies *G. commutatus nagatoensis* as figured by its authors.

Genus IDIOGNATHOIDES Harris and Hollingsworth, 1933

*Type species:* *Idiognathoides sinuatus* Harris and Hollingsworth, 1933; Lower Pennsylvanian, Wapanucka Formation, Oklahoma.

*Remarks:* Harris and Hollingsworth (1933, pp. 193, 194, 200, 201) recognized the existence of three stages of development in the "idiognathoid type" conodonts. They erected the genera *Cavusgnathus* and *Idiognathoides* as representatives of the first two stages, assigning the genus *Idiognathodus* Gunnell to the third stage. The prominent features considered by these authors to be the basis of their classification are the existence of a channel and the development of transverse corrugation on the platform. Thus the genus *Cavusgnathus* was erected to include the lanceolate-plated conodonts with a furrow along the middle of the whole platform and its marginal rims ornamented with denticles, nodes or corrugations. The genus *Idiognathoides* was established to embrace conodonts with the platform anteriorly channelled and posteriorly transversely ridged or corrugated. The genus *Idiognathodus*, representing the end of this lineage, included forms with the median oral channel absent, or merely suggested, on the anterior extremity of the platform, and transverse ridges or nodes on the whole platform.

Harlton (1933, p. 15) erected and published, a few days later than Harris and Hollingsworth, the genus *Polygnathodella* with transverse distinct carinae on the oral surface as main characteristic.

Branson and Mehl (1941, p. 103) suppressed the genus *Idiognathoides*, assuming that *Polygnathodella* and *Idiognathoides* were proposed for the same group and that *Polygnathodella* had publication priority. These authors also transferred the Harris and Hollingsworth species, *I. corrugatus* and *I. attenuatus*, to the genus *Polygnathodella* Harlton.

Ellison and Graves (1941, pp. 8-10) accepted *Polygnathodella* as valid and suppressed *Idiognathoides* as a junior subjective synonym of *Cavusgnathus* on the assumption that the type species of *Idiognathoides* was actually a *Cavusgnathus*.

Merrill (1963, p. 504) accepted the conclusion of Ellison and Graves and stated that *Polygnathodella* and *Cavusgnathus* form a transitional series and that those forms which possess an oral surface with prominent transverse corrugations continuous from one side to the other belong to *Polygnathodella* and those forms with oral, longitudinal non-corrugated troughs belong to *Cavusgnathus*. Huddle (1964, p. 401) stated that the characters used by earlier authors to distinguish the three genera *Cavusgnathus*, *Idiognathoides*, and *Polygnathodella*, i.e. the length of the median trough and the number of ribs crossing the platform, suggest ontogenetic rather than phylogenetic variation. Dunn (1966, p. 1299) erected the genus *Declinognathodus*, with *Cavusgnathus nodulifera*



Ellison and Graves as the type species. This genus has the following characteristics: (a) gnathodid cup, (b) medial juncture of the blade with the platform, (c) declination of the carina to an outer position, and (d) presence of one or more nodes outside the declined carina.

Lane (1967, p. 937) suppressed *Polygnathodella* and *Declinognathodus* as junior synonyms of *Idiognathoides*, and stated that *Cavusgnathus* and *Idiognathoides* are not phylogenetically related, because of a fundamental structural difference in their basal cavities: large, deep, asymmetrical, and located at the posterior end of the platform in *Idiognathoides*; long, narrow, lachrymiform, rather shallow, and situated approximately in the centre of the platform in *Cavusgnathus*. Lane then introduced, with the oral surface ornamentation, the nature and position of the attachment of the blade to the platform as another character to distinguish the different species of *Idiognathoides*.

On the basis of observations on the Murgon specimens the writer believes, in accord with Lane (1967), that *Idiognathoides* is a valid genus and that there is no phylogenetic relation between *Idiognathoides* and *Cavusgnathus*.

*Idiognathoides* could be in its early stage related to the group of *Gnathodus*, showing a parapetlike row of nodes on the platform, anteriorly parallel and posteriorly fused with the carina. Although *Polygnathodella*, because of its characteristic transversely ridged oral surface and its always left-sided attachment of the blade to the carina, could be maintained separated from *Idiognathoides*, the species *I. sinuatus* figured by Lane (1967, pl. 119, figs. 1-9, 12-15) shows the transitional stages from *Idiognathoides* s.s. to *Polygnathodella* s.s., i.e. the development of a corrugated oral surface with a less pronounced furrow in the anterior part of the platform.

In this report the genus *Idiognathoides* is used in the sense of Lane (1967). *Idiognathoides* is a platform genus, with the attachment of a free blade to the platform on either the inner or outer side. A median longitudinal groove of very variable length is present on the platform. A deep, large, asymmetrical basal cavity (gnathodid type) is also considered to be characteristic of the genus, whereas ornamentation on the platform such as transverse ridges or nodes have specific value. *Idiognathoides*, according to Lane (1967), is known to appear in the Prairie Grove Member of the Hale Formation (Morrowan) of Arkansas and to range into Atokan sediments. However Dunn (1966, p. 1299) reported its occurrence from the Bird Spring Formation, Nevada, in material believed to be of Desmoinesian age.

*Idiognathoides corrugatus* (Harris and Hollingsworth)  
Pl. 2, figs. 4-5; pl. 3, figs. 7-8, 22-23, 26

*Idiognathoides corrugata* (Harris and Hollingsworth).  
Lane, 1967, *J. Paleont.*, **41** (4), pl. 122, figs. 1, 2, 4-7, 9-11.

*Material*: 6 specimens (outcrop C, 131; outcrop E, 133)

*Figured specimens*: GSQ MF 005/1, 005/7-005/9.

*Remarks*: Diagnosis, after Lane (1967, p. 939): "A species in which the free blade joins the platform at the right (outer) margin. A carina is not developed. The margins of the platform are of equal height and the plat-

form is ornamented with transverse ridges". The Murgon specimens generally conform to this diagnosis, although in some the platform is slightly convex rather than concave as in Lane's figures.

*Idiognathoides corrugatus* is known to occur in the Cromwell Member of the Wapanucka Formation, Oklahoma (Harris and Hollingsworth, 1933); the Dimple Limestone of the Marathon region, Texas (Ellison and Graves, 1941); the Brentwood Member of the Bloyd Formation, Washington County, Arkansas (Lane, 1967). All are of early Pennsylvanian (Morrowan) age.

*Idiognathoides* aff. *I. noduliferus* (Ellison and Graves)  
Pl. 2, figs. 6-9; pl. 3, figs. 9-11,  
16-17, 24-25, pl. 4, figs. 10-13, 26

*Idiognathoides* aff. *I. nodulifera* (Ellison and Graves).  
Lane, 1967, *J. Paleont.*, **41** (4), p. 938, pl. 123, figs. 9-11,  
13, 16, 17

*Material*: 8 specimens (outcrop A, 37; outcrop B, 124A, 125; outcrop C, 131; outcrop E, 133).

*Figured specimens*: GSQ MF 005/2, 005/10-005/13,  
005/15-005/16.

*Description*: This form closely resembles *Idiognathoides* aff. *I. noduliferus* (Ellison and Graves) described by Lane (1967, p. 938) who, because of its variability, considered it to represent a transitional stage either to *Idiognathoides corrugatus* (Harris and Hollingsworth) or to *Idiognathoides sinuatus* Harris and Hollingsworth. The Murgon specimens are characterized by the lack of nodes outside the carina and by the presence on the platform of a short, very narrow and shallow median trough, which normally disappears in the posterior half giving place to a nodose or ridge row. On the other hand, the possession of a short carina, the ornamentation of the platform with nodes or transverse broad ridges, and a gnathodid-type basal cavity are considered sufficient to indicate affinities to the species under consideration.

*Remarks*: *Idiognathoides* aff. *I. noduliferus* (Ellison and Graves) is known from the Dimple Limestone, Marathon region, Texas, early Pennsylvanian (Ellison and Graves, 1941); the Millstone Grit, Midland Valley, Scotland, Namurian-Westphalian (Clarke, 1960); the Griotte Limestone, north-west Spain, Namurian (Higgins, 1962); the Omi Limestone, early Pennsylvanian, central Japan (Igo and Koike, 1964); and the Prairie Grove Member of the Hale Formation, Morrowan, Arkansas (Lane, 1967).

*Idiognathoides* cf. *I. sinuatus* Harris and Hollingsworth  
Pl. 3, figs. 1-4, 12; pl. 4, figs. 6-9

cf. *Idiognathoides sinuata* Harris and Hollingsworth;  
Lane, 1967, *J. Paleont.*, **41** (4), pp. 937-938, pl. 119,  
figs. 1-9, 12-15, pl. 123, figs. 7, 8, 12.

*Material*: 3 specimens (outcrop B, 125; outcrop C, 131; outcrop E, 133).

*Figured specimens*: GSQ MF 005/5, 005/6, 005/14.

*Description*: Three poorly preserved specimens of *Idiognathoides* are comparable with *I. sinuatus* Harris and Hollingsworth in the following respects. The platform unit has the attachment of the free blade with the carina



at the left (inner) side. The two parapetlike margins bear nodes or short transverse ridges which disappear in the median groove on the platform. This median groove has variable width and length, but does not reach the posterior end. The left margin is slightly higher than the right. Some morphological differences can be found with the species illustrated by Lane, e.g. the more arcuate platform, the free blade normally shorter than the platform, and the basal cavity more expanded just below the attachment of the free blade with the carina.

*Remarks:* *Idiognathoides sinuatus* Harris and Hollingsworth is known from the Wapanucka Formation, Oklahoma (Harris and Hollingsworth, 1933); the Dimple Limestone of the Marathon region, Texas (Ellison and Graves, 1941); the Omi Limestone, central Japan (Igo and Koike, 1964); and the Prairie Grove Member of the Hale Formation and the Brentwood Member of the Bloyd Formation, Washington County, Arkansas (Lane, 1967). All are of early Pennsylvanian age.

*Idiognathoides* cf. *I. tenuis* (Clarke)  
Pl. 4, figs. 24-25

cf. *Polygnathodella tenuis* Clarke, 1960, *Trans. Edin. Geol. Soc.*, 18 (1), p. 28, pl. 5, figs. 12-13.

*Material:* 1 specimen (outcrop C, 130).

*Figured specimen:* GSQ MF 005/18.

*Description:* Broken specimen showing only the posterior part of the unit. The platform is strongly arched with a shallow median groove extending near the posterior tip. The surface of the platform is ornamented with transverse ridges. The attachment of the missing free blade to the carina is on the outer side. The side walls of the platform are vertical or slightly concave and flared near the base.

*Remarks:* This specimen has been compared with *Idiognathoides tenuis* (Clarke) with which it has in common the trenched platform and its general shape. *Idiognathoides tenuis* (Clarke) is known from the Skipsey's Marine Band (Scotland) of Westphalian age (Clarke, 1960).

*Idiognathoides attenuatus* (Harris and Hollingsworth)  
Pl. 4, figs. 22-23

*Idiognathodus attenuata* Harris and Hollingsworth, 1933, *Am. J. Sci.*, 25, pp. 203-204, pl. 1, figs. 9a, b.

*Polygnathodella* spp. Clarke, 1960, *Trans. Edin. Geol. Soc.* 18 (1), pp. 28-29, pl. 5, fig. 16, non fig. 11.

*Material:* 1 specimen (outcrop E, 133).

*Figured specimen:* GSQ MF 005/17.

*Description:* A small specimen of *Idiognathoides* with a rather arcuate platform. The attachment of the free blade with the carina is on the outer side. The platform is ornamented with transverse ridges and shows a concavity toward the anterior part. In oral view the specimen has a slender fusiform aspect. The side walls are slightly concave and near the base they begin to flare. The basal cavity is elongated and occupies the whole aboral side of the platform. This species has been identified as *Idiognathoi-*

*des attenuatus* (Harris and Hollingsworth) by its characteristic slender, lanceolate shape, its arcuate platform, and its very acute posterior end.

*Remarks:* *Polygnathodella* spp. illustrated by Clarke (1960), and found in association with *Idiognathoides tenuis* (Clarke) in Skipsey's Marine Band (Scotland) of Westphalian age, belongs to *Idiognathoides attenuatus* (Harris and Hollingsworth).

Genus *IDIOGNATHODUS* Gunnell, 1931

*Type species:* *Idiognathodus claviformis* Gunnell, 1931; Fort Scott Limestone, Pennsylvanian, Missouri.

*Idiognathodus* cf. *delicatus* Gunnell  
Pl. 5, figs. 1-3

cf. *Idiognathodus delicatus* Gunnell, 1931, *J. Paleont.*, 5 (3), p. 250, pl. 29, fig. 23-25.

cf. *Idiognathodus delicatus* Gunnell. Ellison, 1941, *J. Paleont.*, 15 (2), pp. 134-135, pl. 22, figs. 31-32.

*Material:* 1 specimen (outcrop B, 125).

*Figured specimen:* GSQ MF 007/3.

*Description:* The specimen obtained from the Murgon limestones is a young form, incomplete and badly preserved. Comparison with *I. delicatus* has been established on the following observations. Unit narrow, carina median, extending to the anterior third of the platform; platform flat, with carina and two parallel rows of nodes at each side in the anterior part meeting at right angles the parallel transverse ridges of the posterior part. Sides of the platform vertical, flaring near the base. Aboral cavity elongated, as long as the platform. The specimen under consideration does not show any lateral lobal development of the platform, probably because of its immaturity.

*Remarks:* *I. delicatus* is known from the Dimple Limestone of the Marathon region, early Pennsylvanian, Texas (Ellison and Graves, 1941) and the Des Moines-Missouri Series of Missouri (Cherokee Shale to Stanton Limestone) (Ellison, 1941).

*Idiognathodus* spp.  
Pl. 4, figs. 1-4, 5; pl. 5, fig. 4

*Material:* 3 specimens (outcrop B, 124, 124A, 125).

*Figured specimens:* GSQ MF 007/1, 007/2, 007/4.

*Remarks:* Three poorly preserved specimens of *Idiognathodus* have been illustrated mainly to show the general nature of the assemblage. Two of them can be compared with previously described forms. The specimen illustrated in pl. 4, figs. 1-4 appears close to *Idiognathodus meekerensis* Murray and Chronic (1965, pp. 601-602, pl. 71, figs. 13-29), having in common the following features. In oral view a lanceolate platform, posteriorly pointed and ornamented with transverse ridges. Blade the same size as the platform, continuing as a carina on the anterior half of the platform. The anterior half of the platform shows, from the centre to the sides, a carina, two grooves and two series of nodes that expand toward the external



boundary. In aboral view an elongate basal cavity occupies the aboral surface of the platform and continues as a furrow along the aboral side of the blade.

The broken, incomplete specimen illustrated in pl. 5, fig. 4 resembles *Idiognathodus* sp. figured by Sturgeon and Youngquist (1949, pl. 74, fig. 16).

*Idiognathodus meekerensis* Murray and Chronic occurs in the Minturn Formation, Desmoinesian, Colorado. *Idiognathodus* sp. of Sturgeon and Youngquist is known from the Allegheny Formation, Ohio, of Desmoinesian age.

Genus STREPTOGNATHODUS Stauffer  
and Plummer, 1932

*Type species: Streptognathodus excelsus* Stauffer and Plummer, 1932; Pennsylvanian, Texas.

*Streptognathodus angustus* Dunn  
Pl. 4, figs. 16-17; pl. 5, figs. 6-9, 11-15

*Streptognathodus angustus* Dunn, 1966, *J. Paleont.*, 40 (6), p. 1302, pl. 158, figs. 11, 12, 13.

*Material:* 4 specimens (outcrop B, 124A, 125).

*Figured specimens:* GSQ MF 008/2, 008/5, 008/6, 008/7.

*Description:* These specimens show a narrow lanceolate platform and a carina extending to the posterior tip as a row of nodes. Two narrow nodose parapets are separated from the carina by shallow troughs. The attachment of the blade to the platform is medial. In lateral view the blade denticles decrease in size posteriorly after the junction with the carina. The platform is gently arcuate; the sides are generally vertical or slightly concave and flaring near the base. In aboral view a narrow basal cavity occupies the aboral side of the platform.

*Remarks:* *Streptognathodus angustus* Dunn occurs in the lower Morrowan of the Bird Spring Formation, Clark County, Nevada (Dunn 1966).

*Streptognathodus elegantulus* Stauffer and Plummer  
Pl. 4, figs. 14-15

*Streptognathodus elegantulus* Stauffer and Plummer, 1932, *Univ. Texas Bull.*, 3201, p. 47, pl. 2, fig. 27.

*Polygnathus pawhuskaensis* Harris and Hollingsworth, 1933, *Am. J. Sci.*, 25, p. 199, pl. 1, figs. 12a, b.

*Streptognathodus elegantulus* Stauffer and Plummer, Ellison, 1941, *J. Paleont.*, 15 (2), p. 127-128, pl. 22, figs. 1, 6, 10.

*Material:* 1 specimen (outcrop C, 131).

*Figured specimen:* GSQ MF 008/1.

*Description:* A single incomplete specimen of *Streptognathodus* which possesses a characteristic lanceolate platform, posteriorly pointed and arcuate inward. A medial carina is developed in the anterior third of the platform which has a deep median furrow. Sides of the platform are vertical, slightly concave near the base. Basal cavity elongated, deepest just posterior to the attachment of the carina.

*Remarks:* This specimen seems to agree reasonably well with the descriptions of Stauffer and Plummer (1932)

and Ellison (1941). *Streptognathodus elegantulus* occurs in the Pawhuska Formation, Lower Pennsylvanian, Oklahoma (Harris and Hollingsworth, 1933), and more generally in the Des Moines, Missouri and Virgil Series of North America (Desmoinesian to Lower Permian) (Ellison, 1941).

*Streptognathodus* aff. *S. suberectus* Dunn  
Pl. 4, figs. 18-21

aff. *Streptognathodus suberectus* Dunn, 1966, *J. Paleont.*, 40 (6), p. 1303, pl. 157, figs. 4-6, 10.

*Material:* 1 specimen (outcrop B, 125).

*Figured specimen:* GSQ MF 008/3.

*Remarks:* The specimen appears to be close to Dunn's description and illustrations. The Murgon specimen, however, does not show the lateral lobe of nodes on the inner side. According to Dunn (1966, p. 1303) this is one of the features that characterizes *Streptognathodus suberectus* from *Streptognathodus elongatus* Gunnell (1933, pl. 33, fig. 30). It can be seen from the illustrations of both Dunn and Gunnell that the lateral lobal development is very variable and may be considered to have infraspecific value. Other typical characters of *Streptognathodus suberectus* Dunn, such as the elevated outer parapet and the arcuate platform, are shown by the Murgon specimen.

*Streptognathodus suberectus* occurs in the lower Morrowan of the Bird Spring Formation, Clark County, Nevada, and the Bloyd Shale, Sequoyah County, Oklahoma (Dunn, 1966).

Genus SPATHOGNATHODUS Branson  
and Mehl, 1941

*Type species: Spathodus primus* Branson and Mehl, 1933; Bainbridge Formation, Silurian, Missouri.

*Spathognathodus minutus* (Ellison)  
Pl. 5, figs. 17, 18

*Spathodus minutus* Ellison, 1941, *J. Paleont.*, 15 (2), p. 120, pl. 20, figs. 50-52.

*Spathognathodus minutus* (Ellison). Sturgeon and Youngquist, 1949, *J. Paleont.*, 23 (4), p. 385, pl. 74, figs. 9-11.

*Spathognathodus minutus* (Ellison). Murray and Chronic, 1965, *J. Paleont.*, 39 (4), p. 606, pl. 72, figs. 29, 30.

*Material:* 3 specimens (outcrop B, 124A, 125).

*Figured specimens:* GSQ MF 006/6, 006/7.

*Description:* A blade unit with ten to thirteen laterally compressed denticles. The anterior part of the blade consists of two or three denticles, the second being the main cusp. The angle between the anterior margin and the aboral side is about 60°; with sides vertical, then flaring near the basal cavity. Basal cavity relatively small, centered on the aboral margin, elongated, deeper anteriorly beneath the main cusp.

*Remarks:* *Spathognathodus minutus* occurs mainly in Pennsylvanian strata; it has been found in the Des Moines and Missouri Series (Cherokee Shale to Big Blue Series), Kansas and Missouri, Pennsylvanian (Ellison, 1941); the Dimple Limestone of the Marathon region,



Lower Pennsylvanian, Texas (Ellison and Graves, 1941); the Allegheny Formation, Ohio, Middle Pennsylvanian (Sturgeon and Youngquist, 1949); the Glen Eyrie Formation, Colorado, Lower Pennsylvanian (McLaughlin, 1952); and the Minturn Formation, Colorado, Desmoinesian (Murray and Chronic, 1965). Rexroad and Burton (1961) recorded *Spathognathodus minutus* from the Kinkaid Limestone, uppermost Chesterian, Illinois, which is considered to be the lowermost occurrence of the species.

*Spathognathodus spiculus* Youngquist and Miller  
Pl. 3, figs. 18-20

*Spathognathodus spiculus* Youngquist and Miller, 1949, *J. Paleont.*, **23** (4), p. 622, pl. 101, fig. 4.

*Spathognathodus spiculus* Youngquist and Miller. Rexroad and Furnish, 1964, *J. Paleont.*, **38** (4), p. 674, pl. 111, figs. 20-22.

*Material*: 5 specimens (outcrop A, 37; outcrop E, 133).

*Figured specimens*: GSQ MF 006/3, 006/4.

*Description*: A small blade unit posteriorly slightly arched, with nine or ten laterally compressed denticles. The first two or three anterior denticles are higher and larger than the others and the last is the main cusp. The sides of the blade are vertical with a remarkable flaring at the base, beginning beneath the cusp. The basal cavity is relatively broad and shallow.

*Remarks*: *Spathognathodus spiculus* ranges throughout the Chester Series (Upper Mississippian) of North America (Rexroad and Collinson, 1961).

*Spathognathodus* spp.  
Pl. 3, fig. 5; pl. 5, fig. 16

*Material*: 2 specimens (outcrop B, 124A; outcrop E, 133).

*Figured specimens*: GSQ MF 006/2, 006/5.

*Remarks*: Two forms of *Spathognathodus* that are too altered or incomplete to be more precisely identified. The specimen illustrated in pl. 5, fig. 16 slightly resembles *Spathognathodus scitulus* Hinde (Clarke, 1960, pl. 3, figs. 12-13). The specimen illustrated in pl. 3, fig. 5 can be compared in some features with *S. pusillus* Clarke (1960, pl. 3, figs. 10-11).

*Spathognathodus scitulus* occurs in Upper Mississippian and Pennsylvanian formations of North America and in Namurian formations of Europe. *S. pusillus* is known from the Skateraw Middle Limestones, Dunbar, Scotland, of Upper Carboniferous age (Clarke, 1960). However it has also been recorded in Lower Carboniferous strata (Druce, *pers. comm.*).

Genus OZARKODINA Branson and Mehl, 1933

*Type species*: *Ozarkodina typica* Branson and Mehl, 1933; Bainbridge Formation, Silurian, Missouri.

*Ozarkodina delicatula* (Stauffer and Plummer)  
Pl. 5, figs. 19-21

*Briantodus delicatulus* Stauffer and Plummer, 1932, *Texas Uni. Bull.*, **3201**, p. 29, pl. 2, fig. 27.

*Ozarkodina delicatula* (Stauffer and Plummer). Ellison, 1941, *J. Paleont.*, **15** (2), p. 120, pl. 20, figs. 40-42, 47.

*Ozarkodina delicatula* (Stauffer and Plummer). Rexroad and Burton, 1961, *J. Paleont.*, **35**, p. 1156, pl. 141, fig. 12.

*Ozarkodina delicatula* (Stauffer and Plummer). Dunn, 1965, *J. Paleont.*, **39** (6), p. 1149, pl. 140, fig. 18.

*Material*: 5 specimens (outcrop C, 131; outcrop E, 133).

*Figured specimens*: GSQ MF 009/1, 009/2.

*Remarks*: The Murgon specimens differ from those cited only in the fewer number of denticles, probably because of their immaturity, and in the less pronounced arc of the bar in the specimen figured in pl. 5, figs. 20-21.

*Ozarkodina delicatula* is known from the Upper Devonian to the Upper Permian (Fay, 1952), but occurs more regularly in the Chester Series (Upper Mississippian) of North America.

*Ozarkodina* spp.  
Pl. 5, figs. 22-25, 28

*Material*: 5 specimens (outcrop B, 124A, 125; outcrop E, 133).

*Figured specimens*: GSQ MF 009/3-009/7.

*Remarks*: Of these incomplete specimens, those shown in figs. 22, 23 may be doubtfully related to *Ozarkodina compressa* Rexroad (1957, pl. 2, figs. 1, 2); while that in fig. 24 resembles *Ozarkodina curvata* Rexroad (1958, pl. 4, figs. 1-3).

*Ozarkodina compressa* and *Ozarkodina curvata* are known from the Chester Series of North American (Upper Mississippian) (Rexroad, 1957, 1958).

Genus HINDEODUS Rexroad and Furnish, 1964

*Type species*: *Trichonodella imperfecta* Rexroad, 1957; Chester Series, Mississippian, Illinois.

*Hindeodus imperfectus* (Rexroad)  
Pl. 5, figs. 26, 33

*Trichonodella imperfecta* Rexroad, 1957, *Illin. Geol. Surv. Rept.*, **199**, p. 41, pl. 4, figs. 4, 5.

*Hindeodus imperfectus* (Rexroad). Rexroad and Furnish, 1964, *J. Paleont.*, **38** (4), p. 672, pl. 111, figs. 13, 14.

*Material*: 2 specimens (outcrop B, 125; outcrop E, 133).

*Figured specimens*: GSQ MF 010/1, 010/9.

*Remarks*: The only difference in the Murgon specimens from the types illustrated and described by Rexroad (1957, 1958a), is in the fewer number of denticles on both lateral bars. *H. imperfectus* occurs throughout the Chester Series, Upper Mississippian, of North America.

*Hindeodus* spp.  
Pl. 5, figs. 27, 29-31

*Material*: 4 specimens (outcrop B, 124, 124A; outcrop E, 133).

*Figured specimens*: GSQ MF 010/2, 010/3, 010/4, 010/8.



*Remarks:* Some incomplete or badly preserved conodont specimens which may belong to the genus *Hindeodus* (figs. 27 and 31) can be compared with *Hindeodus alatoides* (Rexroad and Burton, 1961, pl. 140, fig. 8). Figs. 29 and 30 bear resemblances to both the genera *Hindeodus* (Rexroad and Furnish, 1964, pl. 111, fig. 11) and *Ozarkodina* (Globensky, 1967, pl. 55, figs. 1, 10, 14).

Genus SYNPRIONIODINA Ulrich and Bassler, 1926

*Type species:* *Synprioniodina alternata* Ulrich and Bassler, 1926; Chattanooga Shale, Mississippian, Alabama.

*Synprioniodina microdenta* Ellison

Pl. 5, fig. 32

*Synprioniodina microdenta* Ellison, 1941, *J. Paleont.*, 15 (2), p. 119, pl. 20, figs. 43-46.

*Synprioniodina microdenta* Ellison, Murray and Chronic, 1965, *J. Paleont.*, 39 (4), pp. 607, 608, pl. 73, figs. 12, 13.

*Material:* 3 specimens (outcrop E, 133; outcrop B, 124A, 125).

*Figured specimen:* GSQ MF 011.

*Remarks:* This broken specimen agrees closely with the illustration of the type given by Ellison (1941). Main denticle at least twice as large as others, slightly compressed on both sides in direction of limb. Smaller denticles coalesced near the main denticle, becoming discrete and increasing in size toward the extremity. Basal cavity more expanded beneath the main denticle, gradually decreasing toward the limbs.

*Synprioniodina microdenta* Ellison occurs in the Des Moines and Missouri Series of Missouri and Kansas (Ellison, 1941), and in the Dimple Limestone, Marathon region, Texas, of Lower Pennsylvanian age (Ellison and Graves, 1941).

Genus HINDEODELLA Ulrich and Bassler, 1926

*Type species:* *Hindeodella subtilis* Ulrich and Bassler, 1926; Hardin Sandstone, Devonian, Tennessee.

*Hindeodella* spp.

Pl. 6, figs. 1-12, 14-16

*Material:* 23 specimens (outcrops A, B, C, E, 37, 124A, 124, 125, 130, 131, 133).

*Figured specimens:* GSQ MF 012/1-012/15.

*Remarks:* *Hindeodella* is represented by abundant fragmentary specimens. Although several species may be present it does not seem justifiable to make any specific reference.

Genus LIGONODINA Ulrich and Bassler, 1926

*Type species:* *Ligonodina pectinata* Ulrich and Bassler, 1926; Rhinestreet Shale, Devonian, New York.

*Ligonodina* spp.

Pl. 6, figs. 13, 17, 19-21

*Material:* 12 specimens (outcrop B, 124, 125; outcrop C, 130; outcrop E, 133).

*Figured specimens:* GSQ MF 013/1-013/5.

*Remarks:* Several broken specimens of *Ligonodina* only doubtfully comparable with forms figured in the literature were found in the Murgon limestones. Among them, that in fig. 13 could be compared with *Ligonodina typa* (Gunnell) as figured by Ellison (1941, pl. 20, fig. 11); those in figs. 19, 20 resemble *Ligonodina lexingtonensis* (Gunnell) in Ellison (1941, pl. 20, figs. 13-15); while those in figs. 17 and 21 seem to be close to *Ligonodina* sp. as figured by Globensky (1967, pl. 56, fig. 25).

Genus LONCHODINA Ulrich and Bassler, 1926

*Type species:* *Lonchodina typicalis* Ulrich and Bassler 1926; Rhinestreet Shale, Devonian, New York.

*Lonchodina* sp.

Pl. 6, fig. 18

*Material:* 3 specimens (outcrop A, 37; outcrop E, 133).

*Figured specimen:* GSQ MF 014.

*Remarks:* Three fragmental specimens are referred to *Lonchodina*. Their preservation does not allow any further identification.

## FOSSILS OTHER THAN CONODONTS

Microfossils or fossil fragments other than conodonts were found in almost every sample that yielded conodonts. These other fossils can be subdivided into three groups, of which the first two are represented quite abundantly in some samples. The first group consists of arenaceous foraminifera including *Ammodiscus* spp. (pl. 7, figs. 12-14, 17-26) and *Hyperammia* sp. In the residues they are chemically altered, delicate and very fragile.

The second group comprises small fish teeth and fish scales including *Ichthyodus* (?) sp. (pl. 7, figs. 1-6), *Holmesella* sp. (pl. 7, fig. 15) and the fish scale figured in pl. 7, fig. 16.

The third group is represented by a few small fragments of annelid jaws. Very little is known about the stratigraphic distribution of these fossils; nevertheless similar forms have been described in the literature and regarded to be of Pennsylvanian age (Gunnell, 1931, 1933; McLaughlin, 1952; Harris and Hollingsworth, 1933; Harlton, 1933; Murray and Chronic, 1965).

## ACKNOWLEDGEMENTS

The writer thanks Mr. J. T. Woods, present Chief Government Geologist, and Mr. A. K. Denmead, Chief Government Geologist during the early stages of the work, for their encouragement and suggestions.

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#### EXPLANATION OF PLATE 1

All approximately  $\times 60$

FIGS 1–2. *Gnathodus* sp. B, outer and inner views, GSQ MF 001 (outcrop A, 37).

FIGS 3–11, 13–17, 20–21. *Gnathodus* sp. C. 3–5, inner, outer and oral views of a young specimen, GSQ MF 002/1 (outcrop A, 37); 6–8, outer, inner and aboral views of an adult specimen, GSQ MF 002/2 (outcrop A, 37); 9, outer view of a contorted specimen, GSQ MF 002/3 (outcrop E, 133); 10–11, oral views of two adult specimens, GSQ MF 002/4–002/5 (outcrop E, 133); 13–15, outer, inner, and oral views of a young specimen, GSQ MF 002/6 (outcrop A, 37); 16–17, outer and inner views of a contorted specimen, GSQ MF 002/7 (outcrop A, 37); 20–21, outer and inner views of a contorted, chemically altered, adult specimen, GSQ MF 002/8 (outcrop A, 37).

FIGS 12, 18–19, 22–24. *Gnathodus* sp. A. 12, inner view, GSQ MF 003/1 (outcrop B, 125); 18–19, inner and aboral view of a badly preserved adult specimen, GSQ MF 003/2 (outcrop E, 133); 22–24, oral, aboral and outer views of an adult specimen, GSQ MF 003/3 (outcrop B, 125).



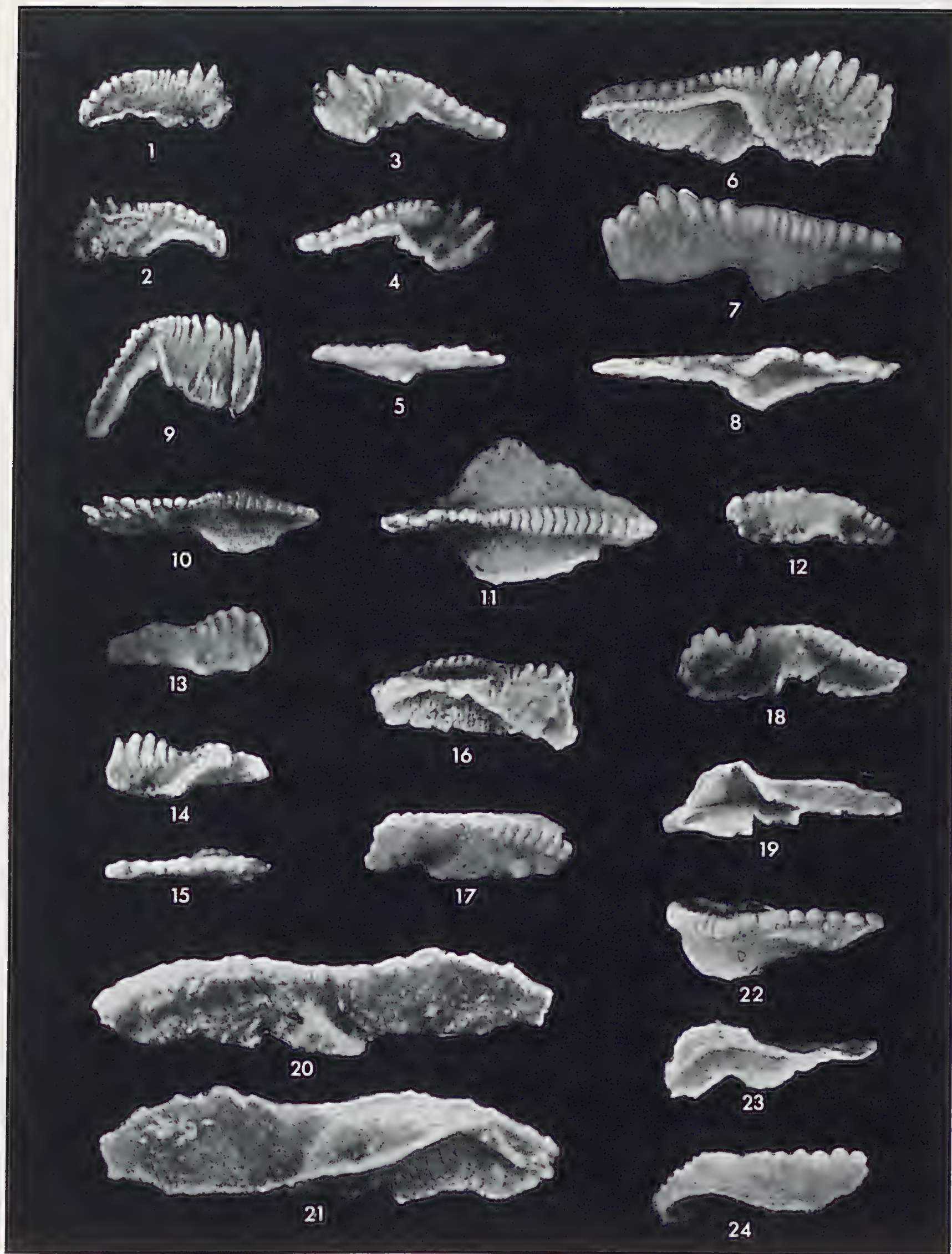


PLATE 1



## EXPLANATION OF PLATE 2

All approximately  $\times 60$

- FIGS 1-3, 10-18. *Gnathodus* sp. C. 1-3, oral, outer and inner views, GSQ MF 002/9 (outcrop B, 125); 10-11, outer and oral views, GSQ MF 002/10 (outcrop E, 133); 12-14, outer, oral and aboral views, GSQ MF 002/11 (outcrop A, 37); 15-18, outer and inner views of two young specimens, GSQ MF 002/12 (outcrop A, 37).
- FIGS 4- 5. *Idiognathoides corrugatus* (Harris and Hollingsworth), aboral and oral views, GSQ MF 005/1 (outcrop E, 133).
- FIGS 6- 9. *Idiognathoides* aff. *I. noduliferus* (Ellison and Graves), inner, outer, oral views, GSQ MF 005/2 (outcrop B, 124A).
- FIGS 21-24, 27, 28. *Gnathodus* sp. A. 21, aboral-lateral view, GSQ MF 003/4 (outcrop E, 133); 22-24, 27, aboral, outer, inner, and oral views, GSQ MF 003/5 (outcrop B, 125); 28, inner view of incomplete specimen, GSQ MF 003/6 (outcrop E, 133).
- FIGS 19-20. *Idiognathoides* (?) sp., inner and oral views of indeterminate fragment, GSQ MF 005/3 (outcrop E, 133).
- FIGS 25-26. *Idiognathoides* (?) sp., oral and inner views of indeterminate fragment, GSQ MF 005/4 (outcrop C, 130).
- FIGS 29-30. *Spathognathodus* (?) sp., outer and inner views of indeterminate fragment, GSQ MF 006/1 (outcrop A, 37).





PLATE 2



### EXPLANATION OF PLATE 3

All approximately  $\times 60$

- FIGS 1- 4, 12. *Idiognathoides* cf. *I. sinuatus* Harris and Hollingsworth. 1-4, outer, aboral, inner, and oral views, GSQ MF 005/5 (outcrop C, 131); 12, oral view, GSQ MF 005/6 (outcrop E, 133).
- FIG. 5. *Spathognathodus* sp., outer view, GSQ MF 006/2 (outcrop E, 133).
- FIGS 6, 21, 27. *Gnathodus* sp. A, inner views, GSQ MF 003/8, 003/7, 003/9 (outcrop E, 133).
- FIGS 7- 8, 22-23, 26. *Idiognathoides corrugatus* (Harris and Hollingsworth). 7-8, oral and outer views, GSQ MF 005/7 (outcrop E, 133); 22-23, inner and oral views, GSQ MF 005/8 (outcrop E, 133); 26, oral view, GSQ MF 005/9 (outcrop E, 133).
- FIGS 9-11, 16-17, 24-25. *Idiognathoides* aff. *I. noduliferus* (Ellison and Graves). 9, oral view of an incomplete specimen, GSQ MF 005/10 (outcrop C, 131); 10-11, outer and oral views, GSQ MF 005/11 (outcrop E, 133); 16-17, inner and oral views, GSQ MF 005/12 (outcrop E, 133); 24-25, oral and outer views of a contorted specimen, GSQ MF 005/13 (outcrop E, 133).
- FIGS 13-15. *Gnathodus* sp. C. 13, outer view, GSQ MF 002/13 (outcrop E, 133); 14-15, outer and inner views, GSQ MF 002/14 (outcrop E, 133).
- FIGS 18-20. *Spathognathodus spiculus* Youngquist and Miller. 18, outer view, GSQ MF 006/4 (outcrop A, 37); 19-20, inner and oral views, GSQ MF 006/3 (outcrop E, 133).



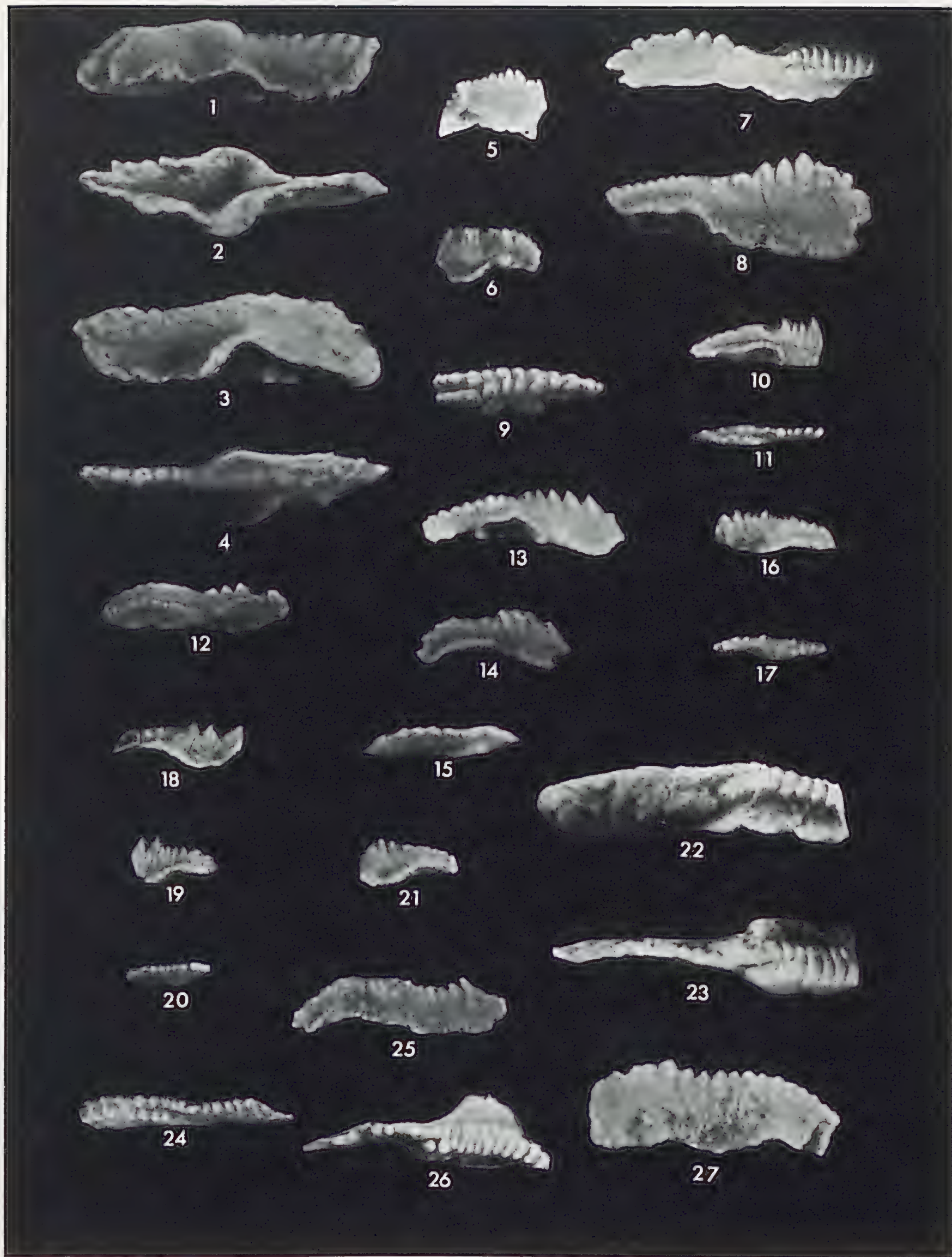


PLATE 3



#### EXPLANATION OF PLATE 4

All approximately  $\times 60$

- FIGS 1–4. *Idiognathodus* sp., outer, oral, aboral, and inner views, GSQ MF 007/1 (outcrop B, 124A).
- FIG. 5. *Idiognathodus* sp., oral view of an incomplete specimen, GSQ MF 007/2 (outcrop B, 125).
- FIGS 6–9. *Idiognathoides* cf. *I. sinuatus* Harris and Hollingsworth, inner, outer, oral and aboral views, GSQ MF 005/14 (outcrop B, 125).
- FIGS 10–13, 26. *Idiognathoides* aff. *I. noduliferus* (Ellison and Graves). 10–13, outer, oral, inner and aboral views of a young specimen, GSQ MF 005/15 (outcrop C, 131); 26, inner view, GSQ MF 005/16 (outcrop E, 133).
- FIGS 14–15. *Streptognathodus elegantulus* Stauffer and Plummer, aboral and oral views, GSQ MF 008/1 (outcrop C, 131).
- FIGS 16–17. *Streptognathodus angustus* Dunn, oral and outer views, GSQ MF 008/2 (outcrop B, 125).
- FIGS 18–21. *Streptognathodus* aff. *S. suberectus* Dunn, oral, outer, aboral, and inner views, GSQ MF 008/3 (outcrop B, 125).
- FIGS 22–23. *Idiognathoides attenuatus* (Harris and Hollingsworth), inner and oral views, GSQ MF 005/17 (outcrop E, 133).
- FIGS 24–25. *Idiognathoides* cf. *I. tenuis* (Clarke), inner and oral views, GSQ MF 005/18 (outcrop C, 130).
- FIGS 27–28. *Gnathodus* cf. *G. bassleri* (Harris and Hollingsworth), inner and oral views of a young specimen, GSQ MF 004 (outcrop E, 133).



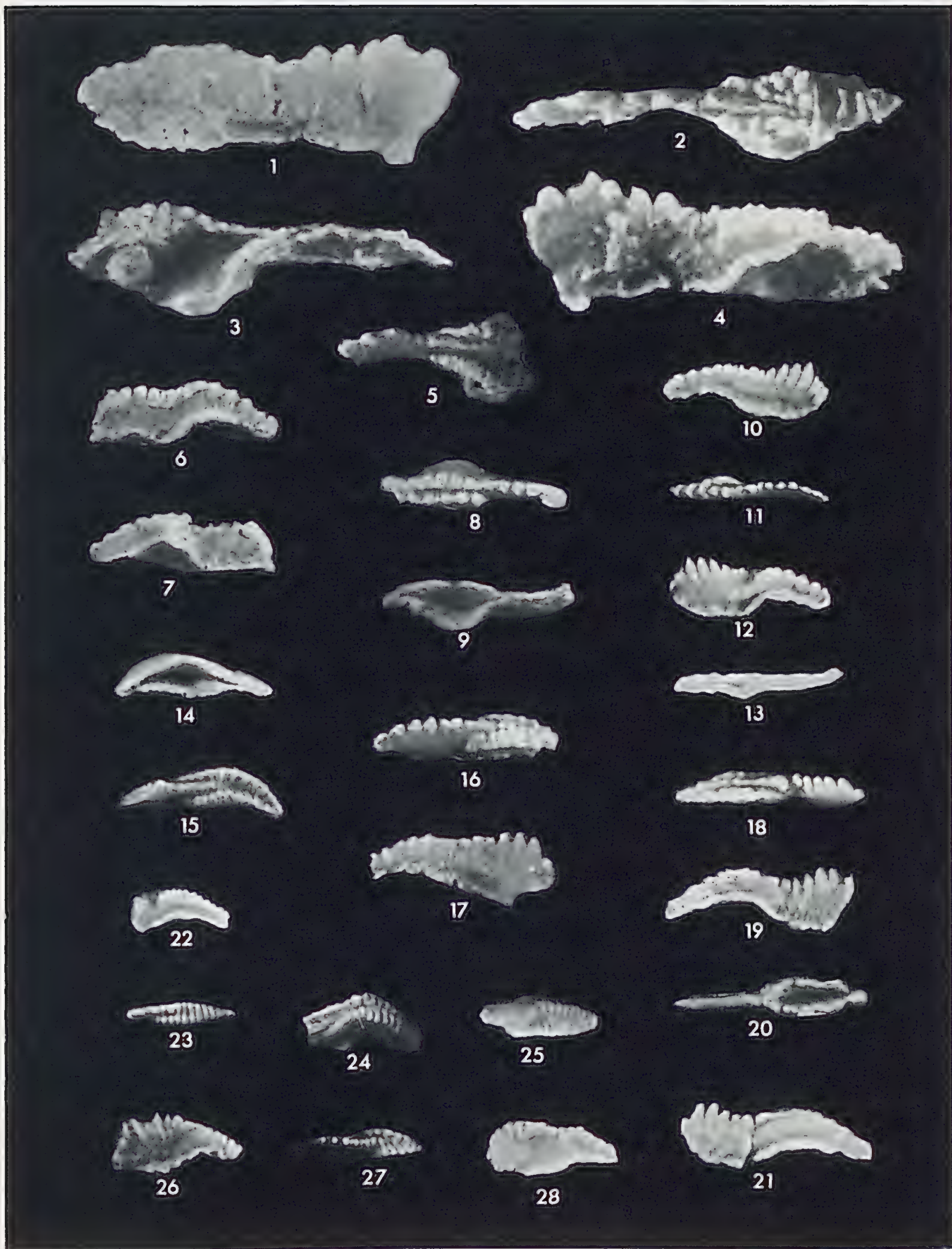


PLATE 4



# EXPLANATION OF PLATE 5

All approximately  $\times 60$

- FIGS 1–3. *Idiognathodus* cf. *I. delicatus* Gunnell, oral, inner, and aboral views of a young specimen, GSQ MF 007/3 (outcrop B, 125).
- FIG. 4. *Idiognathodus* sp., oral view of an incomplete specimen, GSQ MF 007/4 (outcrop B, 124).
- FIG. 5. *Streptognathodus* sp., inner-oral view of an indeterminate fragment, GSQ MF 008/4 (outcrop B, 125).
- FIG. 10. *Idiognathoides* (?) sp., oral view of an incomplete specimen, GSQ MF 005/19 (outcrop E, 133).
- FIGS 6–9, 11–15. *Streptognathodus angustus* Dunn. 6–9, oral, inner, outer, and aboral views, GSQ MF 008/5 (outcrop B, 124A); 11–12, oral and inner views, GSQ MF 008/6 (outcrop B, 125); 13–15, outer, inner, and oral views, GSQ MF 008/7 (outcrop B, 125).
- FIG. 16. *Spathognathodus* sp., outer view, GSQ MF 006/5 (outcrop B, 124A).
- FIGS 17, 18. *Spathognathodus minutus* (Ellison), outer and inner views, GSQ MF 006/6 (outcrop B, 125), GSQ MF 006/7 (outcrop B, 124A).
- FIGS 19–21. *Ozarkodina delicatula* (Stauffer and Plummer). 19, lateral view, GSQ MF 009/2 (outcrop E, 133); 20–21, lateral views, GSQ MF 009/1 (outcrop E, 133).
- FIGS 22–25, 28. *Ozarkodina* spp. 22, 23, outer views, GSQ MF 009/3, 009/4 (outcrop E, 133); 24, 25, 28, lateral views, GSQ MF 009/5, 009/6, 009/7 (outcrop B, 124A, 125; outcrop E, 133).
- FIGS 26, 33. *Hindeodus imperfectus* (Rexroad), lateral views, GSQ MF 010/1 (outcrop E, 133), GSQ MF 010/9 (outcrop B, 125).
- FIG. 32. *Synprioniodina microdenta* Ellison, lateral view, GSQ MF 011 (outcrop E, 133).
- FIGS 27, 29–31. *Hindeodus* spp. 27, 31, lateral views, GSQ MF 010/2, 010/3 (outcrop B, 124, 125); 29, 30, lateral views, GSQ MF 010/4, 010/8 (outcrop E, 133).



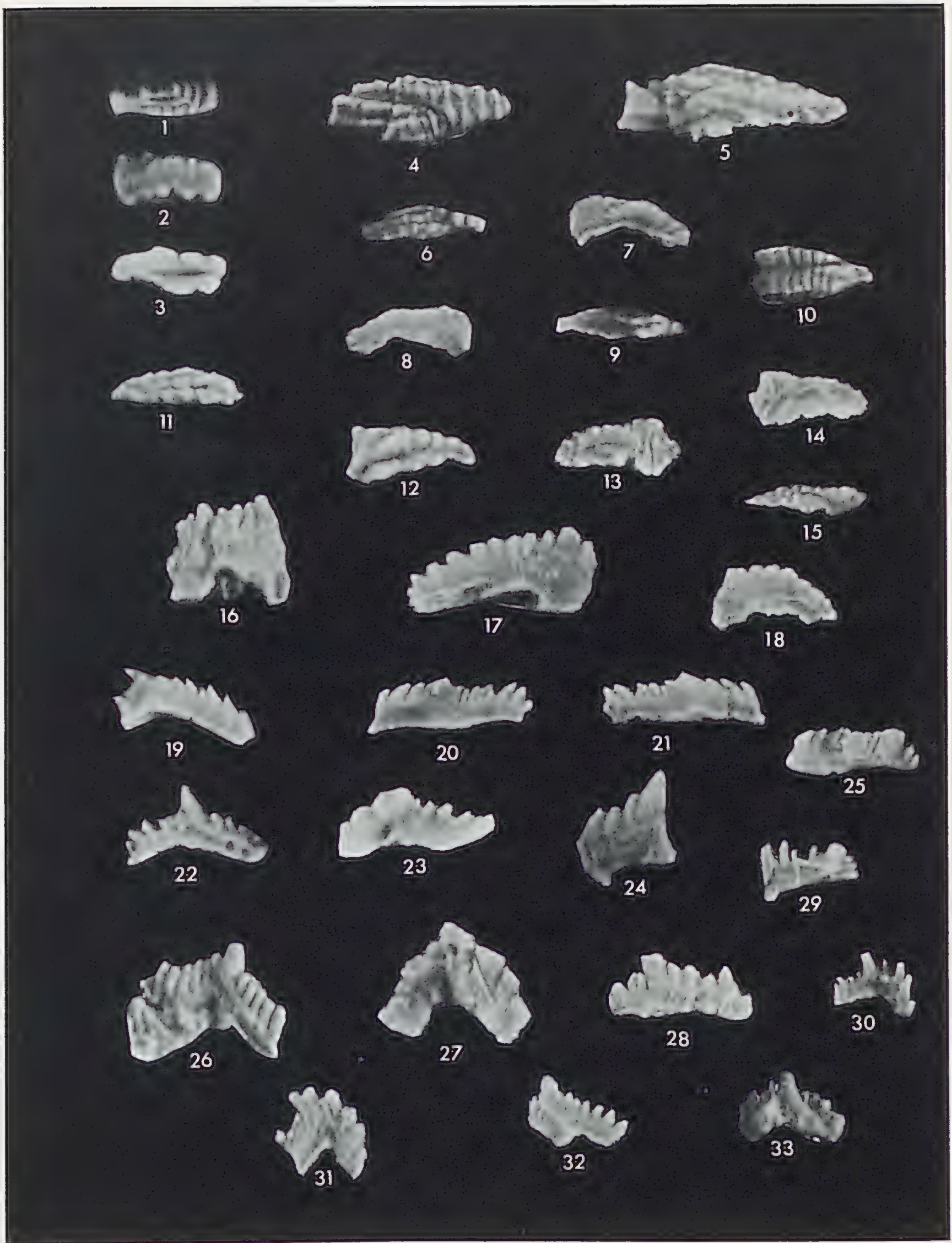


PLATE 5



EXPLANATION OF PLATE 6

All approximately  $\times 60$

- FIGS 1-12, 14-16. *Hindeodella* spp. 1-2, inner and outer views of specimen, GSQ MF 012/1; 3-12, 14-16 side view of specimens GSQ MF 012/2-15 (outcrops A, B, C, E, 37, 124A, 124, 125, 130, 131, 133).
- FIGS 13, 17, 19-21. *Ligonodina* spp., GSQ MF 013/1-5 (outcrops A, B, E, 37, 124A, 125, 133).
- FIG. 18. *Lonchodina* sp., GSQ MF 014 (outcrop A, 37).





PLATE 6



EXPLANATION OF PLATE 7

All approximately  $\times 60$

FIGS 1- 6. *Icthyodus* (?) sp., GSQ MF 015/1-015/6 (outcrop A, 37; outcrop E, 133).

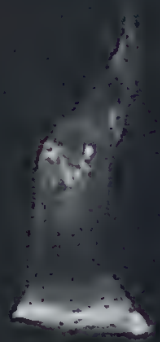
FIGS 7-11. Fish teeth (?), GSQ MF 015/7-015/11 (outcrops A, B, E, 37, 124, 133).

FIGS 12-14, 17-26. *Ammodiscus* sp., GSQ MF 015/12-015/24 (outcrop A, B, C, E, 37, 124, 131, 133).

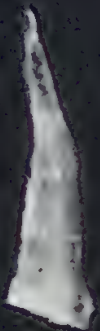
FIG. 15. *Holmesella* sp., GSQ MF 015/25 (outcrop E, 133).

FIG. 16. Indeterminate fragment, probably fish scale remains, GSQ MF 015/26 (outcrops A, 37; outcrop E, 133).

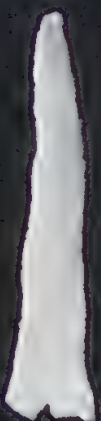




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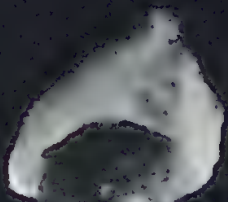
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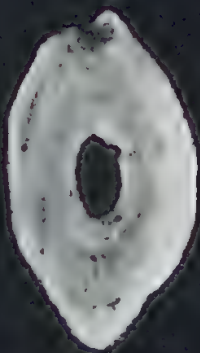
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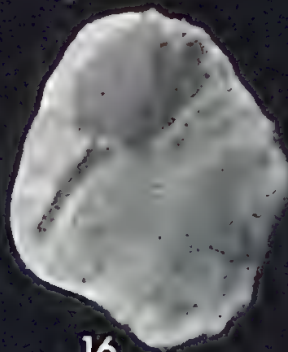
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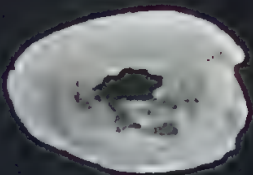
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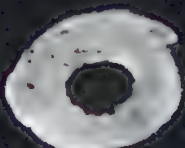
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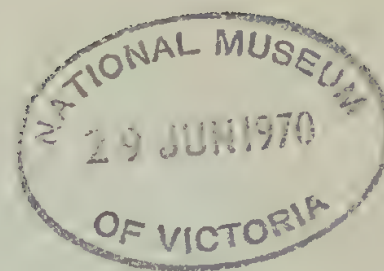




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GEOLOGICAL SURVEY OF QUEENSLAND  
(J. T. Woods, Chief Government Geologist)

PUBLICATION No. 342  
PALAEOONTOLOGICAL PAPERS, No. 18

THE DEVONIAN PRODUCTOID BRACHIOPOD  
FAUNAS OF QUEENSLAND

by  
R. G. McKELLAR



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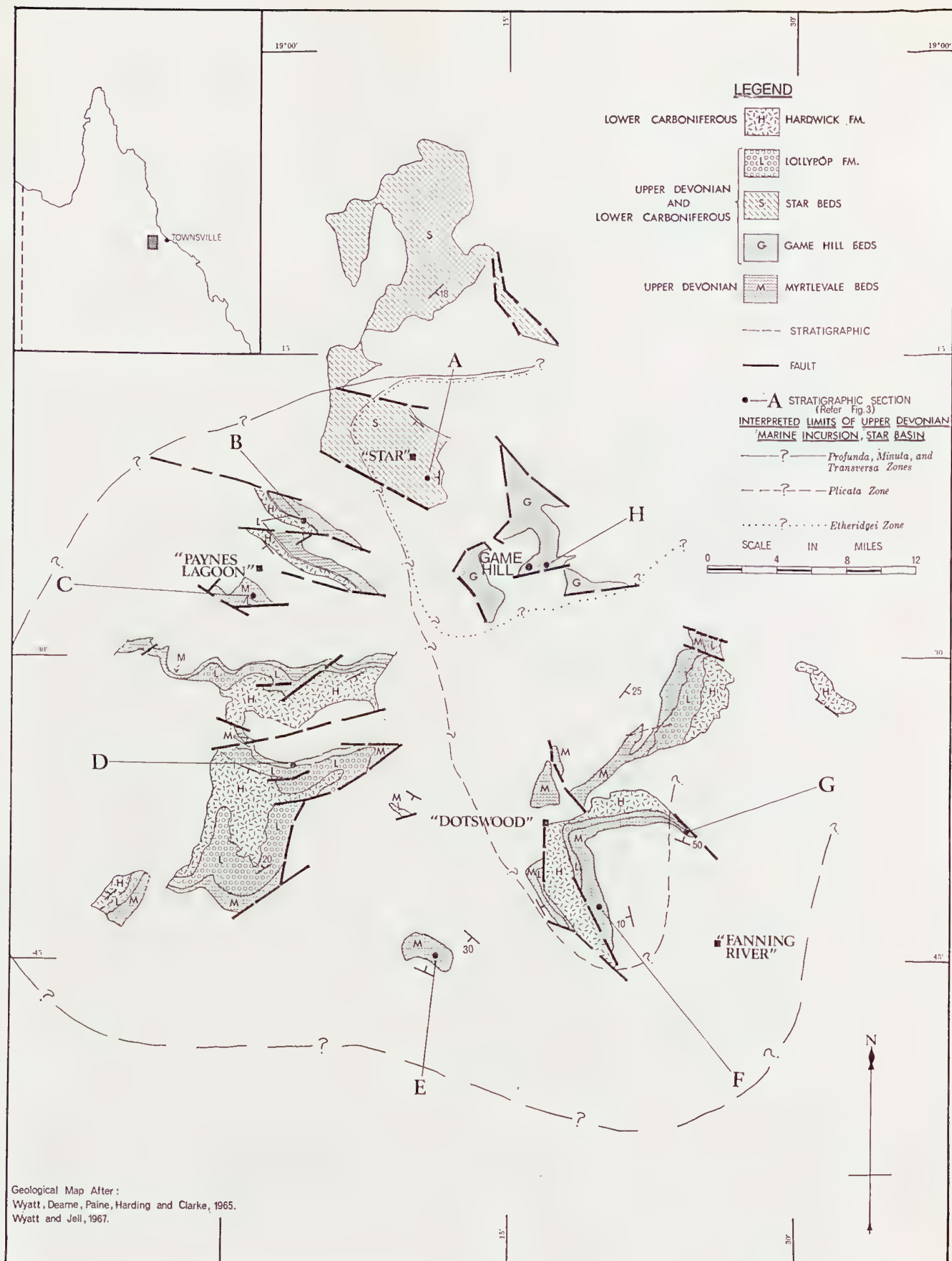


FIGURE 1.—Upper Devonian and Lower Carboniferous formations, and interpreted limits of the Upper Devonian marine incursion, Star Basin.



# THE DEVONIAN PRODUCTOID BRACHIOPOD FAUNAS OF QUEENSLAND

by R. G. McKELLAR

Geological Survey of Queensland\*

## ABSTRACT

Fifteen species and two subspecies of productoid brachiopods belonging to eleven genera are described, and their taxonomy discussed. They are *Australosia starensis* gen. et sp. nov., *Spinulicosta dotswoodae* sp. nov., *Strophoproductus rugosus* sp. nov., *Morganella maxwelli* gen. et sp. nov., *Whidbornella* (*Dotswoodia*) *wyatti* subgen. et sp. nov., *Acanthatia fragilis* sp. nov., *Mesoplica?* *hillae* sp. nov., *Mesoplica?* sp., *Bispinoproductus?* sp., *Semiproductus etheridgei* sp. nov., *Sentosia profunda* sp. nov., *Sentosia minuta* sp. nov., *Sentosia minuta deari* subsp. nov., *Sentosia transversa* sp. nov., *Sentosia transversa caniensis* subsp. nov., *Sentosia plicata* sp. nov., and *Laminatia jacki* sp. nov. One new family, the Sentosiidae, is proposed; the Leioproductidae Muir-Wood and Cooper is revised with the introduction of a new subfamily, the Semiproductinae.

The species above are used to define five assemblage zones in strata of the Star Basin: *Sentosia profunda* Zone, *S. minuta* Zone, *S. transversa* Zone, *S. plicata* Zone, and *Semiproductus etheridgei* Zone. The zonation is taken as the basis for biostratigraphic evaluation of the sedimentary facies relationships, and limits of the Star Basin; for correlation of the areas of late Devonian marine strata in Queensland; and for international correlation for age determination. The main findings are as follows:

(1) During the Famennian, the Star Basin existed as an embayment in the coastline in which seas reached maximum extent in the time of the *S. profunda* Zone, maintained these limits until the time of the *S. transversa* Zone, then regressed progressively northeast, ultimately reducing the region of sedimentation to a small area about Star Homestead, and probably Game Hill, in the time of the *S. etheridgei* Zone. The Famennian strata include the lower portion of the basinal Star and Game Hill Beds, and time-equivalent marginal strata of the Myrtlevale Beds and Lollypop Formation (in part). The upper limit of the lower sandstone unit in the Myrtlevale, Star, and Game Hill Beds, and the boundary between the marine Myrtlevale Beds and terrestrial Lollypop Formation, are each diachronous, youngest in the north, and northeast respectively. The basin was discrete from the Drummond Basin to the south, and Broken River Embayment to the northwest at this time.

(2) The Mt. Wyatt Beds of the Drummond Basin are correlated tentatively with the lower part of the Myrtlevale Beds of the Star Basin; the basal beds of the Boulder Creek Grit at Mt. Morgan, Yarrol Basin, are correlated with the basal Langtry Gully Member of the Dawes Range Formation at Cania, and both predate the Famennian (to III?) marine invasion of the Star Basin; the Milkman Creek, South Kariboe, and Denny Gully Members of the Dawes Range Formation are directly correlated with the *S. profunda*, *S. minuta*, *S. transversa*, and *S. plicata* Zones in the Myrtlevale and Star Beds, Star Basin, by the occurrence of identical species, or slightly different geographic subspecies, of *Sentosia* in the respective units.

(3) International comparison of the faunas in the established zones allowed the following age determinations: the *S. profunda* and *S. minuta* Zones are together assigned the age range Famennian (to III - to IV); the *S. transversa* and *S. plicata* Zones, the age Famennian (to V); the *S. etheridgei* Zone, the age Famennian (to VI). The fauna from Mt. Morgan is regarded as lower Famennian, mainly on its relationship with the independently dated *Cyrtiopsis* aff. *murchisonianus* Fauna at Cania.

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## INTRODUCTION

In Queensland, productoid brachiopods have been collected from late Upper Devonian marine strata in the Star, Yarrol, and Drummond Basins, and from Middle Devonian marine strata in the subsurface Adavale Basin. The study of these brachiopods was begun with the

species from the Star Basin, principally because they appeared to be taxonomically the most diverse element of the fauna there, and thus seemed likely to assist most in the biostratigraphic interpretation of the basin; additionally, because well based age determinations were

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required for the several faunas that could be recognized in the stratigraphic interval represented. To make the study of these brachiopods more comprehensive, and to establish an improved stratigraphic correlation within Queensland, those from the Yarrol Basin in the Mount Morgan and Cania districts were also examined and described. Collections from the Drummond Basin yielded only one incomplete productoid shell, and while this can be noted as probably leioproductid, it was not described. The productoid from the Adavale Basin is represented by more specimens, but its preservation precluded useful description. It occurs in core from the interval 8,400-8,402 feet in Phillips Sunray Bury No. 1 well, located at latitude 25°02'36"S., longitude 145°36'15"E. The interval was interpreted as part of the Bury Limestone Member of the Gilmore Formation by Slanis and Netzel (1967). The species can be identified as *Spinulicosta* or *Helaspis* sp., which indicates an age not older than the Middle Devonian; it is the oldest productoid recorded from Queensland.

Previous work on Devonian productoid brachiopods in Queensland has been extremely limited. From the Star Basin, Wyatt, Paine, Clarke, and Harding (1965), and Wyatt and Jell (1967) listed preliminary identifications of the fauna that had been made by the writer. From the Yarrol Basin, the earliest identifications were made by Maxwell (1953) from strata near Mt. Morgan. Later, Maxwell (1954) described one of the species, and noted another. Dear (1968) listed identifications of brachiopods, including productoids, from Cania near Monto, and made significant conclusions concerning the age of successive faunas there. The species listed had been described by him five years earlier in an unpublished thesis (Dear, 1963a MS). Photographs of Devonian productoids, and accompanying notes, are to be found in two volumes: "Carboniferous Fossils of Queensland" (Hill and Woods, 1964) includes *Sentosia* and "*Rhytiophora*"; "Devonian Fossils of Queensland" (Hill, Playford, and Woods, 1967) includes *Sentosia*, *Mesoplica*, and "*Avonia*". Open nomenclature was used in both publications. The only published works describing such faunas from other States in Australia are those of Veevers (1959a,b) which deal with faunas from the Carnarvon and Fitzroy Basins in Western Australia. Material from the Bonaparte Gulf Basin was listed by Roberts, Jones, and Druce (1967), and is being prepared for publication by Dr. Roberts of the Bureau of Mineral Resources, Canberra.

The preservation of shells in faunas from the Star, Drummond, and Yarrol Basins is remarkably constant. They are all preserved as moulds, often with some remnant carbonate, in various terrigenous sediments—mudstone, siltstone, and sandstone. None are preserved in limestone, and none are silicified. For examination and photography, latex casts from the leached moulds were used extensively.

#### ACKNOWLEDGEMENTS

The writer would like to take the opportunity here to express gratitude to those whose goodwill allowed completion of the project. They are Mr. D. Wyatt, Geological Survey of Queensland, who accompanied the writer and assisted in fossil collection, and examination and measurement of selected sections in the Star Basin during October,

1968, and who was responsible for collecting the bulk of the material from that area used in this publication; Dr. J. Dear, Geological Survey of Queensland, who generously made available collections made by him in the Cania region; Professor D. Hill, University of Queensland, who allowed access to both type and bulk collections of the Department of Geology and Mineralogy; and Mr. J. T. Woods, Chief Government Geologist, for his encouragement in the study.

#### THE PRODUCTOIDS IN BIOSTRATIGRAPHY

##### STAR BASIN: A ZONATION OF FAMENNIAN STRATA

In this section of the paper, a zonation of Famennian strata which contain productoid brachiopod faunas in the Star Basin is introduced and defined. Later it is used as a starting point for correlations within Queensland, and intercontinentally. The zones are conceived as **assemblage zones** which the American Commission on Stratigraphic Nomenclature (1961, p. 656) defined as bodies of "strata characterized by a certain assemblage of fossils without regard to their ranges". In this particular zonation, the definition is based on the productoid brachiopod fauna only, and in this respect is skeletal to a broader zonation which can be set out when the entire fauna has been described. Each assemblage zone receives its name from one of the contained fossils—the guide fossil. As guide fossils, the writer has chosen species of *Sentosia* and *Semiproductus*; the *Sentosia* species are particularly valuable because they are easily recognized, have a wide geographic distribution, and a limited stratigraphic range; the species of *Semiproductus* is almost as valuable because of its distinctiveness and very short range. Because the zones are defined on one taxonomic group, which is never represented by many species in any zone, the range of some species in each may coincide with the limits of the zone, and they then approximate in their characteristics to the indices of range zones; however, this connotation is unintentional. In ascending order, the zones are *Sentosia profunda* Zone, *Sentosia minuta* Zone, *Sentosia transversa* Zone, *Sentosia plicata* Zone, and *Semiproductus etheridgei* Zone. Unfortunately, the earliest Famennian marine strata in the Star Basin, the lower (sandstone) unit in the Myrtlevale, Star, and Game Hill Beds, has only *Cyrtospirifer* and *Camarotoechia* brachiopod faunas and cannot be included in the zonation at this time. An exception is the occurrence of *Spinulicosta* in the uppermost bed of the unit in section E (fig. 2); however the long range of the genus makes its use impracticable in the zonation.

##### *Sentosia profunda* Zone

The assemblage regarded as diagnostic of the zone is *Spinulicosta dotswoodae* sp. nov., *Mesoplica? hillae* sp. nov., and *Sentosia profunda* sp. nov. The zone includes the entire range of *S. profunda*. It has been recognized with certainty only about the southern and southeastern margins of the basin where it comprises a basal silicified siltstone and mudstone member in the upper, fine-grained and predominantly mudstone unit of the Myrtlevale Beds. Elsewhere about the basin, these silicified beds appear to be absent owing to variation laterally in the grain size of the sediment to a sandstone facies which is favoured by *Cyrtospirifer* faunas. The change to a sandy facies has taken place in the Star Beds at the northern margin of the basin (2½ miles northeast of Star Homestead) as strata of the younger *Sentosia minuta* Zone



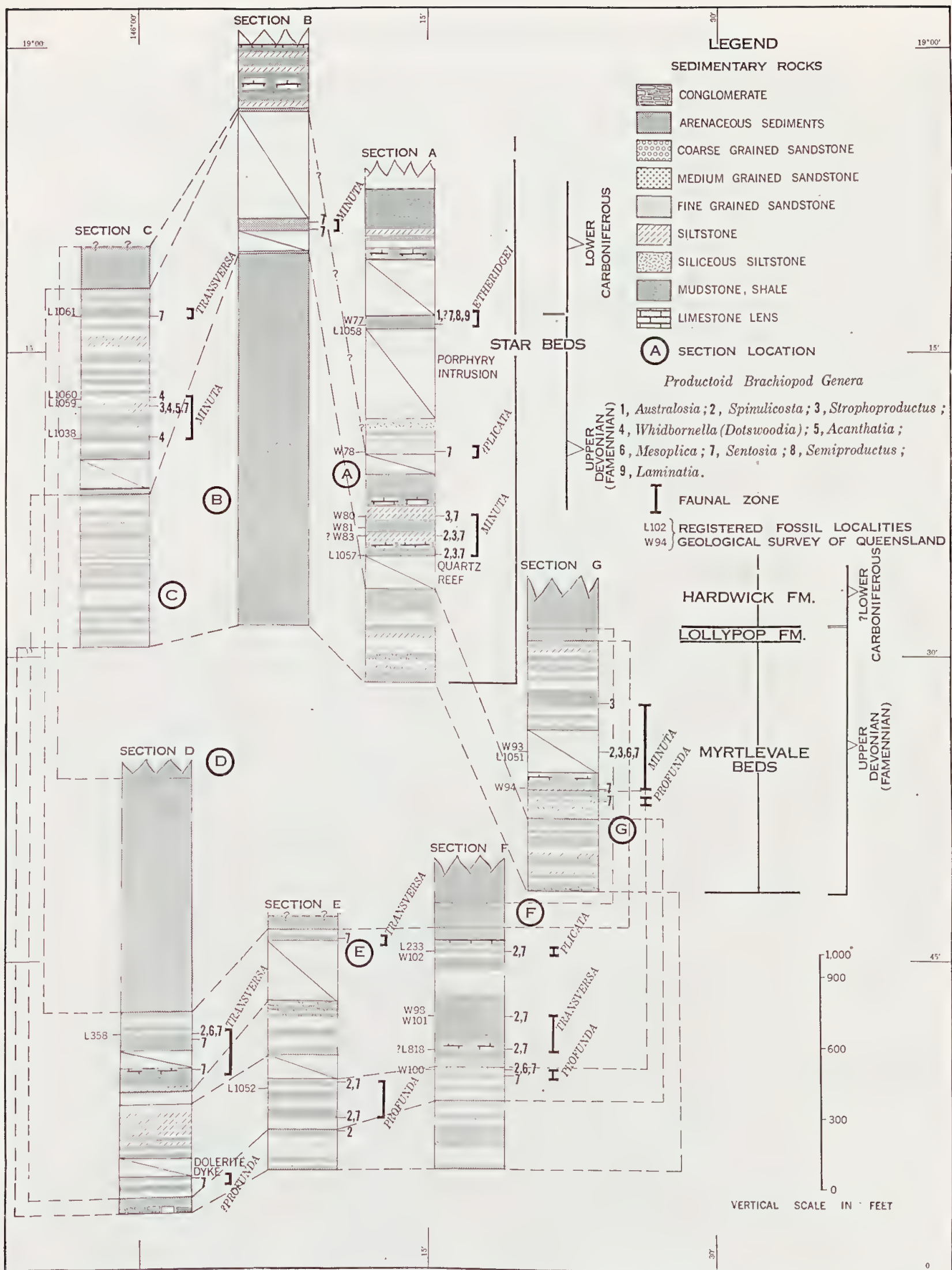


FIGURE 2.—Location and correlation of stratigraphic sections, productoid zones, and productoid faunas in the Upper Devonian marine strata, Star Basin.



there directly overlie sandstone with a *Cyrtospirifer* species characteristic of the *S. profunda* Zone and beds below it. A facies shift may account for similar relationships in the Star Beds at Horse Creek, but a massive quartz vein in this area complicates the picture and introduces the possibility of normal faulting. Thus, the upper limit of the lower sandstone unit in the Myrtlevale and Star Beds seems to be diachronous (fig. 3). The age of the zone is determined later; it is probably the lower part of the interval Famennian (to III - to IV).

#### *Sentosia minuta* Zone

The productoid brachiopod assemblage of the zone is *Spinulicosta dotswoodae* sp. nov., *Strophopproductus rugosus* sp. nov., *Acanthatia fragilis* sp. nov., *Whidbornella* (*Dotswoodia*) *wyatti* subgen. et sp. nov., *Mesoplica? hillae* sp. nov., and *Sentosia minuta* sp. nov. The zone boundaries coincide with the range limits of *Sentosia minuta* in most areas, but in others, they coincide with the range limits of *Strophopproductus rugosus* or *Dotswoodia wyatti*. The stratigraphic position of the zone, above the *S. profunda* Zone is clear in section G, Percy Creek (fig. 2); there is no known overlap between them. The zone is recognized readily in the Myrtlevale and Star Beds across the northern and eastern sides of the basin, but on the southwestern and southern margins a reversion from marine to terrestrial fluvial sedimentation occurred at the time, and the zone is absent. This reversion to terrestrial sedimentation is most marked in section E. In section D, sparsely fossiliferous sediments without a productoid fauna, which represent brackish marine or estuarine deposits, precede wholly terrestrial sediments. In section F, sandy beds low in the upper unit of the Myrtlevale Beds could be interpreted as the limits of the sandstone body in sections D and E in a wholly marine environment. It is not known whether the *S. minuta* Zone is represented in the poorly outcropping beds below this sandy unit. The sandy beds themselves contain *Sentosia transversa* and *Spinulicosta dotswoodae* near Myrtlevale Hut (Townsville 1:250,000 Sheet area) at L818 G.S.Q., and would normally be interpreted as representative of the *S. transversa* Zone; however, the *S. transversa* is more primitive in form than representatives of the species elsewhere, and it may represent an early appearance of the species associated with the sandy facies.

The age of the zone is discussed later; it is regarded as the upper part of the interval Famennian (to III - to IV).

#### *Sentosia transversa* Zone

The productoid brachiopod assemblage of the zone is *Spinulicosta dotswoodae* sp. nov., *Mesoplica? hillae* sp. nov., and *Sentosia transversa*. The zone boundaries coincide with the limits of range of *S. transversa*. The relative position of the zone above the *S. minuta* Zone is indisputably established in section C in the northwest part of the basin; overlap of the two zones may occur in areas of sandy facies (see above), but is unproved. The *S. transversa* Zone represents the youngest strata of the Myrtlevale Beds in a broad zone along the western side of the basin, and probably also in the extreme southeast part about Percy Creek (the latter, judged from the presence of brachiopods which are normally associated with the productoids diagnostic of the zone.) It is overlain by strata including the *S. plicata* Zone in the Myrtlevale

Beds of the Moody Dam area. The zone is not restricted to a particular facies as the guide fossil occurs mainly in siltstone and sandstone beds in the western part of the basin, but in mudstone beds in the Moody Dam area.

The age of the zone is discussed later; it is considered to be Famennian (to V).

#### *Sentosia plicata* Zone

The productoid brachiopod assemblage of the zone is *Spinulicosta dotswoodae* sp. nov., and *Sentosia plicata* sp. nov. The zone boundaries coincide with the range limits of *Sentosia plicata*. Its position stratigraphically above the *S. transversa* Zone is clearly established in section F (Moody Dam area); there is no known overlap. The zone corresponds to the uppermost beds of the Myrtlevale Beds in a restricted area on the eastern side of the Star Basin (fig. 1); however, it is only tentatively identified in the Star Beds of the Horse Creek section. The limited occurrence of this young zone only on the eastern side of the basin is a clear indication of the diachronous nature of the boundary between the Myrtlevale Beds and Lollypop Formation; that is, the boundary is progressively younger proceeding from west to east across the basin (fig. 3B).

The age of the zone is determined in a later section as Famennian (to V).

#### *Semiproductus etheridgei* Zone

The productoid brachiopod assemblage of the zone is *Australosia starensis* gen. et sp. nov., *Semiproductus etheridgei* sp. nov., *Sentosia?* sp. indet., and *Laminatia jacki* sp. nov. Knowledge of the zone is limited to date as the fauna comes from two localities only. The range limits of *Australosia starensis*, *Semiproductus etheridgei* (the guide fossil), and *Laminatia jacki* at present coincide with the boundaries of the zone. The zone has no overlap with the *S. plicata* Zone, which is tentatively recognized stratigraphically well below it in Section A, Horse Creek (fig. 2). The zone occurs in the middle of the Star Beds in the northeast part of the Star Basin in an area that takes in the southern block of the Star Beds, and probably also in the Game Hill Beds (fig. 1). Its lateral equivalents would be the terrestrial sandstone facies of the Lollypop Formation (fig. 3A,B).

The age of the zone is discussed later; it is regarded as Famennian (to VI), the latest beds of the Devonian.

#### STAR BASIN: FAMENNIAN HISTORY

**Nomenclature.** The name Star Basin is applied to an area north of Charters Towers and west of Townsville, where marine and terrestrial sedimentation occurred in the interval upper Middle Devonian to Lower Carboniferous, and in part of which, sedimentation was continuous for that interval of time. The name Star Basin was first employed by Jack in Jack and Etheridge (1892, p. 128) in relation to the area of deposition of the Star and Dotswood Beds, of Upper Devonian and early Carboniferous age. Since then it has been recognized that the history of uninterrupted sedimentation in the area is much longer, and embraces the period of deposition of the upper Middle Devonian Fanning River Group (of Wyatt and Jell, 1967). It is the writer's contention that because a basin remains the same element of structure whether it was defined initially on the basis of one or all of its parts, then the name employed initially for one part



of the basin automatically becomes the name for the entire structure when that is recognized. By this reasoning, the name Star Basin should be retained, but with its definition extended to take in the earliest phase of sedimentation in the structure. The basin was interpreted in the latter sense by Hill (1951, p. 16; 1960, p. 8).

Whitehouse (1930, p. 29) introduced the name Burdekin Basin for an area of sedimentation "around the Broken, Clarke, and Fanning Rivers" (but exclusive of that about Reid River) where Middle and Upper Devonian, and Lower Carboniferous strata were deposited. The Broken River region, later the Broken River Embayment (of Hill, 1960; Jell in Wyatt and Jell, 1967), and the Fanning River region in the Star Basin (of Hill, 1960), have not been shown to have been connected directly at any time during their history, although it is conceivable that they were during periods of maximum marine transgression in the upper Middle Devonian and Lower Carboniferous. Wyatt *et al.* (1965, p. 21) also recognized basins, are regarded by the writer as discrete areas of active subsidence during the Devonian and Lower Carboniferous. Wyatt *et al.* (1965, p. 21) also recognized the likelihood of the two regions having somewhat different sedimentary and tectonic histories. They restricted the Burdekin Basin to an area bounded on the west by a line linking Laroona, Valpre, and Burdekin Downs Homesteads, and on the east by a line linking Fanning River Homestead, Calcium, and Speeds Creek, *i.e.* to the area of development of the Burdekin Formation (of Jack in Jack and Etheridge, 1892; Wyatt in Wyatt and Jell, 1967). Thus the Burdekin Basin was restricted by removal from its western side of the Broken River Embayment, but enlarged on its eastern side by inclusion of the Reid River Basin of Whitehouse (1930, p. 29). This latter usage of Burdekin Basin, which in fact nearly corresponds to that of the Star Basin (of Hill, 1960), was again employed by Wyatt in Wyatt and Jell (1967). The writer regards the modified usage of the name Burdekin Basin in a geologic sense as redundant, firstly because it is synonymous with the name Star Basin, and secondly because the name is applied in a hydrologic sense to the catchment basin of the Burdekin River.

In the area of the Star Basin, marine incursions occurred during two intervals of time: the first in the upper Middle Devonian when the Fanning River Group was deposited, the second in the late Devonian (Famennian) and early Carboniferous (Tournaisian) when the marine Star Beds and equivalent stratigraphic units were deposited. The history of this last marine phase can be interpreted from the biostratigraphy, and is outlined below.

#### A Biostratigraphic Assessment

The stratigraphic units that have been defined to describe the succession of late Devonian and early Carboniferous marine and terrestrial strata in the Star Basin are indicated in figure 3A. Their relationships along a general northeast-southwest section line with respect to horizontal time lines are indicated, together with a rationalized nomenclature, in figure 3B. Some of the units in this latter figure are entirely informal and the simplified nomenclature must be taken only as a guide for future stratigraphic redefinition. The current stratigraphic units are described in outline, but in relation to the new zonation, in the account below.

*Myrtlevale Beds* (Wyatt, Paine, Harding, and Clarke, 1965; Wyatt and Jell, 1967). These beds comprise a lower, predominantly sandstone unit, and an upper, predominantly mudstone unit; they overlie terrestrial red beds of the Dotswood Formation (Jack, 1879) in all areas. The lower unit is thickest in the northern part of the Famennian basin, and is thinnest in the southwest and west (fig. 2). It is everywhere quartzose in the basal part (protoquartzite, quartz-feldspar sandstone, granule and pebble quartz conglomerate); in the upper part, it is very feldspathic (brown and pink arkose, feldspathic sandstone, minor subgreywacke) about the southern side of the basin (fig. 2, sections E, F, G), but much more lithic (green and grey-green subgreywacke, subordinate feldspathic sandstone), and in the upper beds fine grained and siliceous, about the north of the basin (fig. 2, sections B, C). This sandstone unit lacks a productoid brachiopod fauna, and as the zonation stands, it is not included; however, an elongate species of *Cyrtospirifer* and *Camarotoechia*, both of which occur in the *Sentosia profunda* Zone, occur in all sections examined, except section D near Piccadilly Bore. The fauna appears about the middle of the section in the east (section G), later further west and north. The unit deserves formation status, and the name Payne Lagoon Sandstone is suggested as appropriate (fig. 3B).

The upper unit of the Myrtlevale Beds is typically developed in the southeastern part of the basin between Moody Dam and Myrtle Vale Hut. The stratigraphically lowest sediments about the southern side of the basin are brown, extremely siliceous siltstone and silty mudstone. These fossiliferous beds are the *Sentosia profunda* Zone, and are regarded as a special facies, equivalent to the upper siliceous beds of the lower sandstone unit about the north of the basin. Firstly, because the elongate *Cyrtospirifer* mentioned above is found in both the sandstone unit and *S. profunda* Zone siltstone in the south, but only the sandstone unit in the north; secondly, because the *Sentosia minuta* Zone overlies the *S. profunda* Zone in the south, but overlies the sandstone unit in the north. Completely normal marine strata, represented by the *Sentosia minuta* Zone, occur only in the southeast and north of the basin in the Myrtlevale Beds. They include brown mudstone beds with thin platy limestone lenses and sandy beds with *Cyrtospirifer* coquinas. On the western side of the basin, the zone has abnormal marine faunas. In section C (fig. 2), strata including brown, blocky and flaggy siltstone, shale, and mudstone with an atypical marine fauna [*Whidbornella* (*Dotswoodia*), *Acanthatia*, *Sentosia*, *Strophoproductus*] are separated by an interval of 100 feet of shale and mudstone with a rich and exclusive association of *Lingula* sp. and *Leptophloeum australe* (McCoy). Modified marine, perhaps estuarine, and littoral conditions are interpreted for the faunas respectively. *Acanthatia* occurs only in the western marginal area of the basin in section C, and at L343 and L345 G.S.Q., further south. In section D, near Piccadilly Bore, thick (160-170ft) grey and greenish-brown, blocky and flaggy micaceous siltstone beds are overlain by white quartz-feldspar sandstone and protoquartzite beds (35 feet), fine grained at the base, coarse grained above. The siltstone beds have a modified marine fauna of *Cyrtospirifer*, *Mucrospirifer*, *Camarotoechia*, and molluscs; the sandstone has *Cyrtospirifer* fragments in the basal bed, but is unfossiliferous except for *Lepto-*



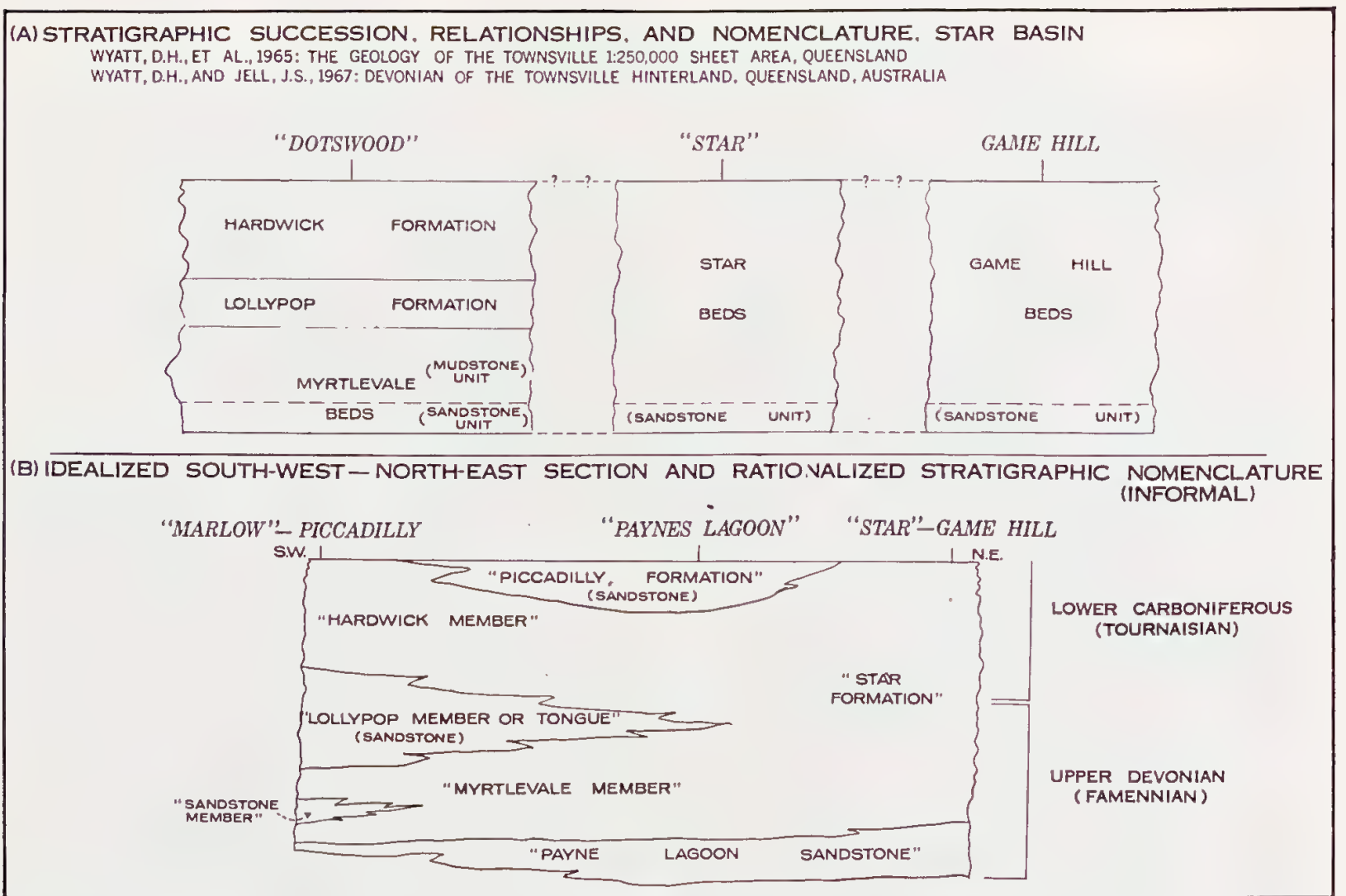


FIGURE 3.—Relationships of late Devonian and early Carboniferous stratigraphic units, Star Basin.

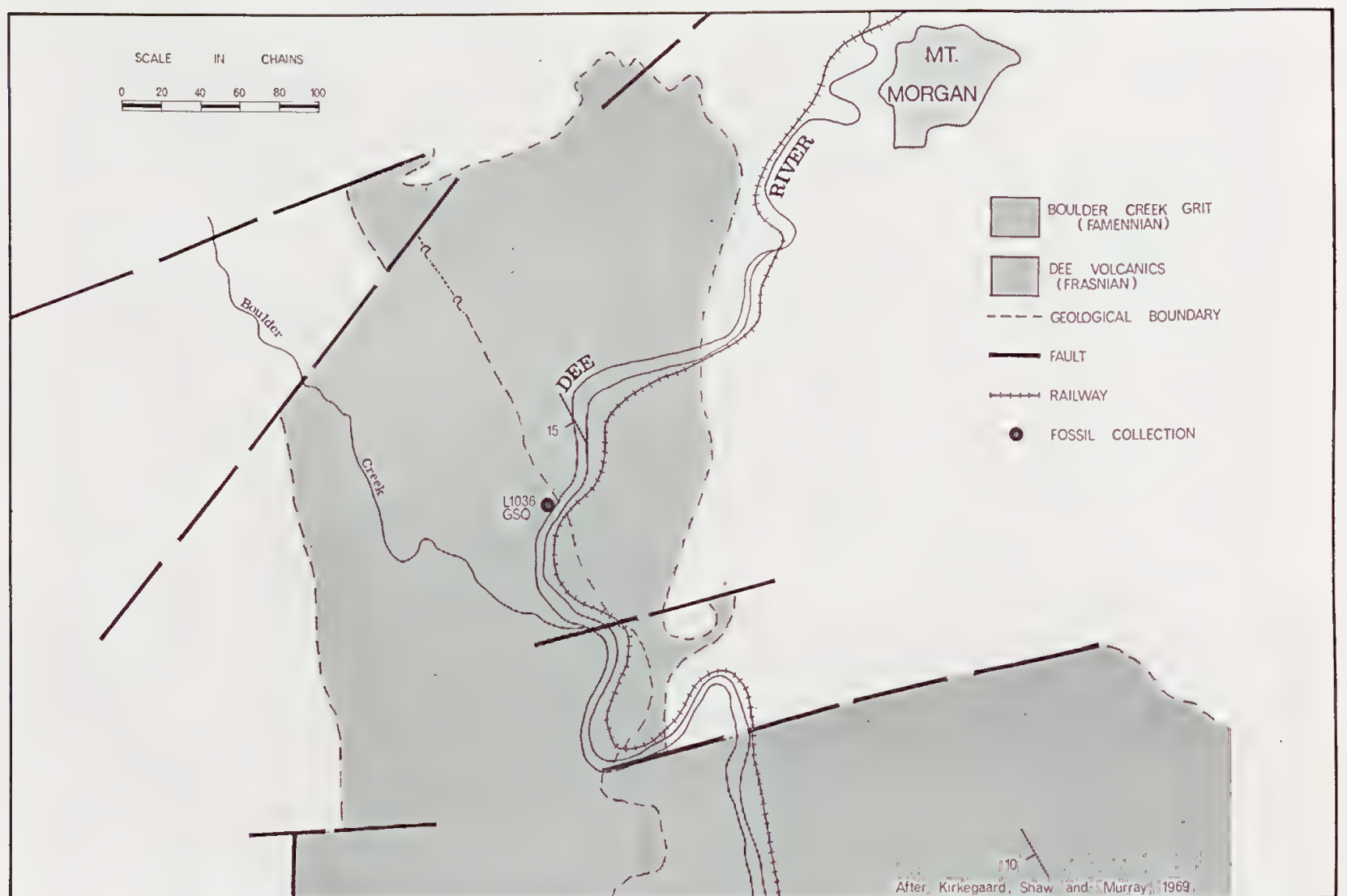


FIGURE 4.—Upper Devonian formations, and collection locality for Famennian brachiopods, Mount Morgan.



*phloeum* above. It is well sorted, and broadly cross-bedded. In section D, in the southwest portion of the basin, the interval above the *S. profunda* Zone is occupied by beds (with an aggregate thickness of *ca* 235 feet) of coarse white feldspathic protoquartzite and granule and pebble quartz conglomerate. The beds are unfossiliferous, well sorted, and very strongly cross-bedded. The cross-beds are relatively small scale structures of trough and festoon types; those few foresets measured dipped to the northeast. Like the coarse sandstone in section C, they are regarded as terrestrial, fluvial deposits.

Overlying strata in the Myrtlevalle Beds, represented by the *Sentosia transversa* Zone, appear to be fully marine in all parts of the basin. On the east side (section F), they comprise interbedded brown mudstone and thin, very fine, flaggy sandstone beds; some muddy limestone lenses occur. In the western region (sections C, D) similar strata were deposited, but micaceous, quartz feldspar sandstone becomes the main rock type at the top. In this western region, and in the extreme southeast, the *S. transversa* Zone is overlain by quartz sandstone and conglomerate of the Lollypop Formation. The youngest beds in the formation occur only in the central eastern region (section F), where brown mudstone with thin beds of chocolate-coloured muddy limestone and calcareous siltstone is overlain by light-brown micaceous and calcareous sandstone, brown mudstone, and muddy limestone of the *Sentosia plicata* Zone. The whole interval is characterized by a *Tenticospirifer* fauna (fully marine). The Lollypop Formation overlies these beds.

*Lollypop Formation* (Wyatt *et al.*, 1965; Wyatt and Jell, 1967). The formation was not investigated in the field, except where it was very thin, and thickness estimates come from the above works, or from unpublished maps drawn by Mr. D. H. Wyatt. Rock types are protoquartzite, feldspathic sandstone, granule and pebble quartz and quartzite conglomerate. The plant *Leptophloeum australe* (McCoy) has been found at several horizons; the marine fossils *Lingula* sp., *Camarotoechia* sp., and *?Modiomorpha* sp. were recorded by Wyatt and Jell (1967, table 2), from the uppermost beds. The formation is very thick in the southwest portion of the basin (more than 2,000 feet), but it thins away to the north (section B, 50 feet), to the northeast (absent in Star Beds, section A), and to the east (section G, less than 100 feet). It would seem to be a fan-shaped deposit, like the sand about the southwest of the basin in the Myrtlevalle Beds. The formation is overlain by the Hardwick Formation.

*Hardwick Formation* (Wyatt *et al.*, 1965; Wyatt and Jell, 1967). This is a marine, predominantly brown and grey mudstone and shale formation with arkose and subgreywacke interbedded in the lower part; an unfossiliferous calcilutite above; and in the upper part, feldspathic ferruginous sandstone, feldspathic sandstone, and bioclastic limestone. The fauna is indicative of a Lower Carboniferous (Tournaisian, Cu I and Cu IIa) age. It was not examined for the present study.

*Piccadilly Formation* (Wyatt *et al.*, 1965). This is a non-marine succession of arkose, feldspathic sandstone, and granule and pebble quartz conglomerate that occurs only along the western side of the basin. It may be a terrestrial facies, equivalent to the upper part of the Hardwick Formation (fig. 3B) as it overlies Hardwick Formation, represented by early Tournaisian mudstone and siltstone

with *Leptophloeum* in section B, but significantly younger (Cu IIa) beds of the same formation near Piccadilly Bore to the south. No fossils are known from the formation.

*Star Beds* (Jack, 1879; Wyatt *et al.*, 1965; Wyatt and Jell, 1967). The beds overlie Argentine Metamorphics unconformably in the east, and thin red beds of the Dotswood Formation conformably in the northwest and immediately to the north of Star Homestead. They comprise a lower, mainly sandstone unit and an extremely thick upper, mainly mudstone, unit.

The lower unit has protoquartzite, pebbly feldspathic sandstone, and quartz conglomerate at its base. Overlying strata are grey-green siltstone, feldspathic sandstone, subgreywacke, and flaggy, micaceous, feldspathic sandstone, in ascending order. A calcareous horizon in the upper beds has a coquina of elongate *Cyrtospirifer*. The unit is known only in the Star Homestead region, and varies in thickness from 400 feet at Horse Creek to 3,000 feet north-northwest of the homestead (*fide* Wyatt *et al.*, 1965, p. 36). It is closely analogous to the sandstone unit at the base of the Myrtlevalle Beds.

The overlying strata are indicated on figure 2 (section A). The succession of rock types is green-brown mudstone with large calcareous septarian nodules and very thin bioclastic limestone lenses at various horizons (*Sentosia minuta* Zone); fine-grained siliceous sandstone, calcareous siltstone, and brown mudstone (*?Sentosia plicata* Zone, *Tenticospirifer* fauna); brown mudstone, thin muddy limestone lenses (*Semiproductus etheridgei* Zone); dark grey and brown shale with a persistent inorganic calcilutite (12 feet) at the top (*Brachythyris*, *Cyrtina*, *Leiorhynchus* fauna); brown mudstone, shale, muddy limestone, feldspathic sandstone, pebble and granule conglomerate (*Prospira* aff. *typa*, *Retzia?* sp., *Avonia* cf. *kennedyensis* fauna). Only the upper two groups of strata of Tournaisian age have been recognized in northern outcrop regions of the Star Beds. The upper unit of the beds has a thickness in excess of 2,000 feet, of which 1,000-1,100 feet are Devonian in age. The unit is a lateral wholly marine facies equivalent of the upper unit of the Myrtlevalle Beds plus the Lollypop and Hardwick Formations.

*Game Hill Beds* (Wyatt *et al.*, 1965; Wyatt and Jell, 1967). They occur in an isolated, structurally-complex outcrop area about Game Hill on the eastern side of the basin. They are only 4 miles distant from the Star Beds and do not differ significantly from them. A thick fossiliferous sandstone bed occurs in the early Tournaisian mudstone succession, 120 feet stratigraphically below the main inorganic limestone.

**Synthesis.** The second marine incursion into the Star Basin began in the Famennian in a rapidly subsiding embayment, or gulf, in the Devonian coastline. The lower sandstone-conglomerate units of the Myrtlevalle, Star, and Game Hill Beds are regarded as marine transgressive sediments that supplanted the fluvial and lacustrine red beds of the Frasnian and early Famennian Dotswood Formation. The white protoquartzite and feldspathic sandstone beds at the base are interpreted as reworked sediment of the Dotswood Formation; the later influx of feldspathic, quartzose, and lithic sand came from marginal source areas presumably rejuvenated by the subsidence. The area of deposition was probably little



greater than the present area of outcrop (fig. 1). Across the south, the abundance of arenaceous feldspar seems to indicate proximity to a granitic source—the Lolworth-Ravenswood axis; across the north, Devonian strata are absent in the Star Beds north of the Star Homestead block, and the great thickness of lithic arenaceous and rudaceous sediment indicates an elevated volcanic source close by; across the west and southwest, the unit is extremely thin, and close to its limits. Marine faunas occur lowest stratigraphically on the east side of the basin, but inconstantly, and only in the uppermost beds on the west side. The relationships of the *Sentosia profunda* Zone indicate a diachronous upper boundary for the sandstone—youngest along the north side of the basin. Relatively rapid transgression is suggested by the lack of “up-sequence” differentiation in the fauna of the sandstone.

The upper unit of the Myrtlevale Beds, and the equivalent strata in the Star and Game Hill Beds, are not known to overlap the lower sandstone unit at the margins of the basin. The occurrence of fine-grained rocks of the *Sentosia profunda* Zone only at the southern margin of the basin suggests that source topography there approached a mature form earlier than elsewhere. In the succeeding *Sentosia minuta* Zone, normal marine conditions occurred across the eastern and northern sides of the basin; probably estuarine and littoral conditions in the northwest and west; ?terrestrial, fluvial conditions in the southwest. The sandstone-conglomerate tongue in the southwest could represent a fan deposit spreading from a fault scarp at the margin, or alternatively, represent terrestrial fluvial deposits that advanced basinwards during a period of minimal subsidence and regression there. Strata of the *Sentosia transversa* Zone are marine throughout the basin. They are sandy in their upper part and overlain by terrestrial Lollypop Formation in the western and southeastern regions of the basin; in the east-central region of the basin (fig. 1), they are muddy in their upper part, and overlain by marine mudstone, sandstone, and limestone of the Myrtlevale, Star, and Game Hill Beds. These upper beds, represented in part by the *Sentosia plicata* Zone, are in turn overlain by the Lollypop Formation, except in the northeast of the basin where fully marine conditions continued in a much contracted area, with open access to the ocean, about Star Homestead and Game Hill. Thus, the upper boundary of the Myrtlevale Beds is clearly diachronous, and youngest in the northeast.

The Lollypop Formation is a massive wedge-shaped sandstone and conglomerate fan, which thins along its axis toward the northeast. Like the sandstone-conglomerate body which interrupts the marine Myrtlevale Beds, it is interpreted as a terrestrial fluvial body that in its lower part advanced behind the regressing Famennian sea, and later contracted ahead of the transgressive Tournaisian sea. The latter reworked the upper beds and marine fossils were deposited in them. The upper Famennian-early Tournaisian age for the unit follows from its interfingering relationship with marine sediments representative of that time interval.

The Tournaisian transgressive sea deposited the upper part of the Star and Game Hill Beds, and the Hardwick Formation, and for a time before its withdrawal extended well beyond the limits of the Famennian sea. In the east,

Hardwick Formation occurs in the Hervey Range; in the north, the Star Beds extended at least 15 miles beyond the Famennian shoreline; and in the northwest, Hardwick Formation occurs in the region of Laroona and Lassie Creek Stations (Wyatt *et al.*, 1965, p. 40, 41). It is likely that the upper Tournaisian sea was continuous to the northwest into the Clarke River Basin (of Hill, 1960, p. 8). The occurrence of Piccadilly Formation, probably as the terrestrial facies-equivalent to the Hardwick Formation along the west side of the basin, suggests that this area was emergent. The Hardwick Formation is not known to overlap the Lollypop Formation on the south side of the basin, and the granitic axis there presumably remained structurally high.

From the above relationships, it seems reasonable to say that there was no connection across the Lolworth-Ravenswood axis between the Star and Drummond Basins at any time during the late Devonian and early Carboniferous. This supports the conclusions of Hill (1960, p. 9, fig. 1), and Hill and Maxwell (1962, fig. 1), but is contrary to those of Brown, Campbell, and Crook (1967, p. 137, fig. 5, 6) who envisaged drainage from the Amadeus Basin, through the Drummond and Star Basins to the Hodgkinson Trough. While connection with the Clarke River Basin and thence to the Bundock Creek region of the Broken River Embayment may have been established during the period of maximum transgression in the upper Tournaisian, it is considered improbable before that time. It is interesting to note that maximum transgression occurred at the same time in both the Star and the Yarrol Basins, and the control may have been eustatic rather than epeirogenic.

#### CORRELATION OF THE LATE DEVONIAN MARINE STRATA, QUEENSLAND

Late Devonian (Famennian) marine strata were deposited in three basins in Queensland. They are the Star Basin of the Charters Towers-Townsville district (Myrtlevale Beds, Star Beds, Game Hill Beds); the Drummond Basin, in its northeastern part about Ukalunda Homestead (Mount Wyatt Beds); and the Yarrol Basin, in the Cania district (Dawes Range Formation and ?lower beds, Three Moon Conglomerate), Mount Morgan district (?upper beds, Dee Volcanics, and Boulder Creek Grit), and on ?Long Island in Broad Sound. The broad stratigraphic relationships in each of these regions was indicated by Hill (1967, table 1). The detailed correlation of the units has as its basis the zonation defined in the foregoing section for the Star Basin; however, the spiriferacean faunas must be relied upon quite heavily.

**Drummond Basin.** The marine incursion into this basin was very limited and occurred only at its northeastern extremity where the Mount Wyatt Beds of Daintree (1870), and Malone, Jensen, Gregory, and Forbes (1966, p. 10) were deposited. The marine fauna is dominated by *Cyrtospirifer* sp., a moderately elongate form like that from the lower (sandstone) unit and the *Sentosia profunda* Zone of the Myrtlevale Beds, but includes also rare *Chonetes* sp. indet., and a leioproductid brachiopod. The latter is represented in the Geological Survey collections by a single incomplete brachial valve which resembles generally that of *Mesoplica? hillae* sp. nov. The species of *Cyrtospirifer* may give the most reliable guide



to the relationship between the Mt. Wyatt Beds and the Myrtlevale Beds.

### Yarrol Basin

(a) Cania. In the Cania district, near Monto, the Dawes Range Formation (Dear, 1968) was deposited during the Famennian in a trough that extended from the Mount Morgan region. Miogeosynclinal conditions of vulcanicity, rapid subsidence, and rapid, shallow-water deposition prevailed in the area. Dear recognized four component members in the succession of lithic arenite, siltstone, conglomerate, and intermediate volcanic rocks; in ascending order, they are Langtry Gully Member, Milkman Creek Member, South Kariboe Member, and Denny Gully Member. The Langtry Gully Member is characterized by the *Cyrtiopsis* aff. *murchisonianus* Fauna (Dear, *op. cit.*, p. 6) which includes, in addition to the nominate species, the cyrtospiriferids *Cyrtiopsis* aff. *orbelianus* (Abich), *Cyrtospirifer reidi* Maxwell, and *Cyrtospirifer subdisjuncta* Maxwell. [A productoid, *Productella*? sp., listed in the fauna, is represented by a single brachial valve which has some resemblances to *Morganella maxwelli* but is too poorly preserved to permit accurate comparison—Ed.] The age of the fauna is lower, or early upper, Famennian (Dear, *op. cit.*, p. 7). The faunal assemblage of the Milkman Creek Member was described (p. 6) as the *Mesoplica* aff. *praelonga* Fauna; the diagnostic species are the productoids *Mesoplica* aff. *praelonga* (Sowerby) and *Sentosia* cf. sp. nov. *a*. The former is described herein as *Mesoplica*? sp., the latter is represented moderately well in collection L1991 U. Q., and this material is confidently referred to *Sentosia profunda* sp. nov. Correlation is made with the *S. profunda* Zone, Myrtlevale Beds, Star Basin (Famennian, to III - to IV).

The brachiopod assemblage of the South Kariboe Member was listed by Dear (p. 7, table 1) as part of the *Cyrtospirifer sinensis* var. *australis* Fauna. The incoming of *Cyrtospirifer sinensis* var. *australis* (Maxwell) in the member is significant, but the occurrence of *Sentosia* sp. nov. *a*, described herein as *Sentosia minuta deari* subsp. nov., is more important for correlation purposes. The *Sentosia* is regarded as a geographic subspecies of *S. minuta* sp. nov., and it allows correlation with the *S. minuta* Zone of the Myrtlevale and Star Beds (Famennian, to III - to IV), Star Basin. The brachiopod assemblage of the Denny Gully Member constitutes the second part of the *Cyrtospirifer sinensis* var. *australis* Fauna. The incoming of *Tenticospirifer grandis* Maxwell in the lower beds of the member is significant, as too is the appearance of the transverse *Sentosia*, listed as *Sentosia* sp. nov. *b* by Dear (p. 7, table 1), and described herein as *S. transversa caniensis* subsp. nov. It is taken as a geographic subspecies of *S. transversa* sp. nov., and establishes correlation with the *S. transversa* Zone of the Myrtlevale Beds (Famennian, to V), Star Basin. The productoid listed as *Sentosia* sp. nov. *b* from the uppermost beds of the member (L2251 U. Q.) is confidently assigned to *S. plicata* sp. nov. This species establishes correlation between the upper beds of the Denny Gully Member, and the *S. plicata* Zone (Famennian, to V) of the Myrtlevale and Star Beds, Star Basin. The Famennian (to VI) *Semiproductus etheridgei* Zone has not been recognized in the Cania district; it may correspond to the

lower, unfossiliferous portion of the Three Moon Conglomerate.

(b) Mt. Morgan. In the Mt. Morgan district, the stratigraphic and biostratigraphic succession was described originally by Maxwell (1953, 1954). His Upper Devonian and early Carboniferous formations and zones in ascending order are Dee Volcanics, Thomson Clastics (*Cyrtospirifer* Zone), Boulder Creek Grit (*Sulcatospirifer* Zone), and Pond Argillite (*Tenticospirifer* Zone and *Chonetes* Zone). Kirkegaard *et al.* (1969) have further clarified the stratigraphic succession. The Thomson Clastics was regarded by them as an invalid unit because its type section is mainly within the upper beds of the Dee Volcanics, and because its boundaries (Maxwell, 1953, Geological Map) make an angle of approximately 40° to the regional strike in the typical area. They include the fossiliferous sandstone, mapped as Thomson Clastics in the area to the north of the Dee River, in the basal beds of the Boulder Creek Grit with which it has lithologic analogy. The name Thomson Clastics is for the above reasons discarded here.

The oldest Upper Devonian strata are the Dee Volcanics. Limestone and sandstone beds near the middle of the formation contain Frasnian brachiopods and corals (McKellar, 1966). Coarse lithic arenites at L995 G.S.Q. (fig. 4), that belong either to the uppermost beds of the Dee Volcanics, or to the base of the revised Boulder Creek Grit, contain *Cyrtiopsis* aff. *murchisonianus* (de Verneuil). Similar shell beds at the base of the Boulder Creek Grit, or close to it, north of the Dee River have an abundance of *Cyrtospirifer reidi* Maxwell associated with two uncommon productoids, *Morganella maxwelli* gen. et sp. nov. and *Bispinoproductus*? sp., of Famennian age. The presence of both *Cyrtospirifer reidi* and *Cyrtiopsis* aff. *murchisonianus*, which mark the *Cyrtospirifer* Zone, in or close to the base of the Boulder Creek Grit strongly suggests correlation of the zone with the lower Famennian Langtry Gully Member (*Cyrtiopsis* aff. *murchisonianus* Fauna), Dawes Range Formation.

The *Sulcatospirifer* Zone in the upper part of the Boulder Creek Grit in Golden Gully does not include productoid brachiopods. At the localities L1192U. Q. and L1195U. Q., the cyrtospiriferid *Sulcatospirifer primus* Maxwell is associated with *Tenticospirifer* cf. *grandis* Maxwell, *Schuchertella* sp., and *Camarotoechia* sp. in dark-grey siliceous argillite. The incoming of *Tenticospirifer* cf. *grandis* there may correspond to that in the lower part of the Denny Gully Member at Cania (Famennian, to V). The *Tenticospirifer* Zone was based on faunas from the east side of Kennedy Creek in strata that Maxwell (1953, Geological Map) mapped as Pond Argillite. A. G. Kirkegaard (*pers. comm.*) informs me that he has examined the area carefully, and the rock types there must be assigned to the Boulder Creek Grit. On this basis, the zone is placed in the upper beds of the Boulder Creek Grit. Maxwell (1954) described four species from the zone—*Productella* sp., *Dimegasma elegans* Maxwell, *Tenticospirifer grandis* Maxwell, and *Mucrospirifer kennedyensis* Maxwell. One specimen (F59310U. Q.) of '*Productella* sp.' was located in the University of Queensland collection from L1197U. Q.; it can be identified only as *Chonopectinae* gen. et sp. indet. Unrecorded species associated are *Schizophoria*



aff. *pierrensis* Veevers, *Rhipidomella* sp., *Schuchertella* sp., and *Camarotoechia* sp.; they occur in grey argillite. The zone has *Tenticospirifer* and *Schuchertella* in common with the *Sulcatospirifer* Zone, and may represent a similar stratigraphic interval. This will require field checking. The *Chonetes* Zone in the Pond Argillite contains *Tulcumbella tenuistriata* (Maxwell) which is indicative of a Tournaisian (Cu I) age (Campbell and McKellar, 1969; McKellar, 1969).

(c) Long Island. Roberts (1963) tentatively identified *Cyrtospirifer* in samples from this island. As they have not been seen, only their occurrence is recorded.

[(d) Cape Hillsborough. Dear (1963)b recorded *Cyrtospirifer* and an indeterminate productoid, possibly *Sentosia*, from the Campwyn Beds on Outer Red Cliff Island, near Cape Hillsborough north of Mackay—Ed.]

### INTERNATIONAL CORRELATION OF THE ZONES

#### THE DEVONIAN-CARBONIFEROUS BOUNDARY

At the second Heerlen Congress on Carboniferous Stratigraphy in 1935 (Jongmans and Gothan, 1937), it was agreed that the Devonian-Carboniferous boundary should be fixed at the junction, or interface, between the German goniatite zones of *Wocklumeria* and *Gattendorfia*, this position marking the upper limit of range of the clymenid goniatites. The decision has been confirmed by recent congresses on Carboniferous stratigraphy and by the 1967 International Symposium on the Devonian System at Calgary. Acceptance of the upper limit of the *Wocklumeria* Zone (to VI) as the upper limit of the Devonian has been quite general, with the notable exception of stratigraphers in the USSR. The usage adopted in that country coincides with that proposed in 1927 at the first Congress on Carboniferous Stratigraphy (Jongmans, 1928) which placed the limit of the Upper Devonian at the top of the *Gonioclymenia* Zone; that is, the Strunian, or Etroeungtian, was regarded as Carboniferous. Stepanov (1964, p. 790) indicated that in the USSR the accepted lower limit of the Carboniferous was the base of the Zone of *Wocklumeria* in the cephalopod facies, and the base of the Zone d'Etroeungt and its analogues (Zone K with *Cleistopora*, and Strunian) in the brachiopod-coral facies. It seems likely that the scarcity of goniatite faunas in most strata of the Russian platform areas prompted the decision, as the stratigraphic equivalents of the base of the Zone d'Etroeungt are easily recognized and correlated inter-regionally in the brachiopod-coral facies, e.g. by the extinction of *Cyrtospirifer*. The practice of placing the *Wocklumeria* Zone in the Carboniferous has been pursued to the present time, and in papers prepared for the 1967 International Symposium on the Devonian System, the limit of the *Clymenia laevigata* Zone (Rzhonsnitskaya, 1967, p. 344; Tszyu, 1967, p. 400) and that of various *Cyrtospirifer* zones, e.g. *Cyrtospirifer insulcifer sphaeroidea* Zone (Avrov, 1967, p. 454), *Cyrtospirifer romanouskii* Zone (Brezhnev, 1967, p. 446), were used to mark the upper boundary of the Devonian. Thus, the basal zone of the Russian Carboniferous is equivalent in age normally to the Zone d'Etroeungt, and elsewhere should be regarded as Upper Devonian (to VI). Such zones include the Malevski Zone ( $C_1^{ml}$ ) on the Russian Platform, the Abishevski Zone of the Kuznetz

Basin, the Tarkansk Zone or Suite of the Rudny Altai, and the Etroeungt Beds of Armenia.

The use of the stage name Famennian is inconstant in Europe. This has occurred because the upper limit of the Devonian System no longer coincides with that of the Famennian, as defined originally from the north of France and south of Belgium. Mamet (1967) has explained that in this type area, the limit of the Devonian (*Wocklumeria*, to VI) is to be found in the lower Tournaisian Stage, and he places it at the top of the Tournaisian 1B approximately; that is, at the top of the Calcaire d'Hasstiere and Calcaire des Avesnelles, and above the Calcaire d'Etroeungt. In Germany, where the goniatite zones have their origin, the interval including the zones to II - to VI is designated the Famennian with the substages, in ascending order, Nehdenian (to II), Hembergian (to III, to IV), and Dasbergian (to V, to VI) (Erben and Zagora, 1967). Thus, the German Famennian is of longer duration than that of France and Belgium. Because the goniatite zonation is based on the German Famennian and is the accepted basis for international correlation, this usage of Famennian has become very widespread, and is used in this paper. Examples of its use are: Britain (House, 1963; Goldring *et al.*, 1967), Canada (Norris, 1967), Western USA (Poole *et al.*, 1967; Sandberg and Maple, 1967), and Western Australia (Johnstone *et al.*, 1967; Roberts, Jones, and Druce, 1967). As indicated earlier, in the USSR the Famennian virtually coincides with that defined originally from the type area of France and Belgium. The Cassadagan and Bradfordian Stages of northeastern USA are approximately equivalent to the German Famennian (Collinson, 1967; Oliver *et al.*, 1967).

Goniatite zones have been used traditionally to mark the Devonian-Carboniferous boundary because it has been the strong contention of many palaeontologists that goniatites are rapidly and widely dispersed geographically, and relatively unaffected by facies owing to their presumably nektonic existence. The boundary can be recognized adequately, and accurately, using several other groups of invertebrate organisms—conodonts, foraminifera, trilobites, and brachiopods. Using the conodonts, the boundary is placed at the junction of the *Spathognathodus costatus* Zone and the *Siphonodella sulcata* Zone (Ziegler, 1962, 1965). With the foraminifera, the boundary is marked by either the top of the *Quasiendothyra kobeitusana* Zone [of Mamet (1967), not Lipina (1964)], or the extinction of the Quasiendothyrinae. Using the trilobites, the extinction of the Phacopina is a valuable indicator. The brachiopods are particularly useful for the definition of the boundary. The extinction of *Tenticospirifer* occurs at, or very close to, the upper limit of *Wocklumeria* (to VI); however, in my experience, *Cyrtospirifer* ranges only to the limit of *Clymenia* (to V), and as noted before, has been used extensively to mark the top of the Russian Famennian. The extinction of any of the productoids *Orbinaria*, *Chonopectus*, *Sentosia*, and *Mesoplica* is quite a precise indication of the limit of *Wocklumeria* and the German Famennian. The horizon is marked also by the extinction of the Productellinae Muir-Wood and Cooper, 1960.

#### CORRELATION AND AGE DETERMINATION

The zones defined for the Upper Devonian succession in the Star Basin represent limited stratigraphic thicknesses, and indeed, very short intervals of time. For the



purpose of international correlation, a partial grouping of zone faunas is proposed, as the more comprehensive assemblages then available for comparison undoubtedly give a more balanced result. Furthermore, the productoids from the Yarrol Basin that have been assigned to the zones, or correlated with them, in the previous sections are taken into account. The zones, and groups of zones, to be discussed are, in descending order:

- (1) *Semiproductus etheridgei* Zone
- (2) *Sentosia plicata* and *S. transversa* Zones
- (3) *Sentosia minuta* and *S. profunda* Zones

#### *Semiproductus etheridgei* Zone

The total productoid fauna of the zone is *Australosia starensis* gen. et sp. nov., *Sentosia?* sp. indet., *Laminatia jacki* sp. nov., and *Semiproductus etheridgei* sp. nov. *Australosia* is a strophalosiid genus whose affinities appear to be with the upper Middle Devonian *Devonalsia*; however, the analogy is very general, and contributes little to the problem of age determination. *Sentosia?* sp. indet. is known only from three poorly preserved moulds of pedicle valves and should be ignored; however, if the identification is correct, it is significant as *Sentosia* ranges only to the limit of Famennian (to VI). *Laminatia* has a limited stratigraphic distribution. In the USA it occurs in Colorado, in the Chaffee Formation (Dyer Member), and in the lower part of the Ouray Limestone [Zone of *Spirifer animasensis* Girty, Famennian (to V); Poole et al., (1967)]; and in New Mexico, in the Box Member of the Percha Formation—Famennian (to V, to VI). The genus is identified doubtfully herein also from the USSR in the Tarkansk Suite (brachiopod layer), Rudny Altai (German Famennian, to VI). *Semiproductus etheridgei* appears to most closely resemble *S. minax* Bublitschenko from the Tarkansk Suite, Rudny Altai, and Abishevski Zone, Kusnetz Basin, which are of latest Famennian (to VI) age.

The association of *Laminatia* and *Semiproductus* is indicative of a Famennian (to V - to VI) age, but the extinction of *Spinulicosta* in underlying beds (see following section) would suggest that the *S. etheridgei* Zone should be assigned a Famennian (to VI) age.

#### *Sentosia plicata* and *S. transversa* Zones

The combined productoid assemblage from both Star and Yarrol Basins is *Spinulicosta dotswoodae* sp. nov., *Mesoplica? hillae* sp. nov., *Sentosia transversa* sp. nov., *S. transversa caniensis* subsp. nov., and *S. plicata* sp. nov. The interval is significant because it includes the stratigraphically highest occurrences of *Spinulicosta* in Queensland. The genus is the primary stock of the Productellidae, and ranges from the Eifelian (Onondaga Limestone, N.Y.) to Famennian (to V). At this time, dentition appears to have been lost, and the late species gave rise to forms such as *Productus niger* Gosselet and *Productus bassus* Vaughan. I can find no positive identifications of *Spinulicosta* from Famennian (to VI) strata.

The interval also includes advanced species of *Sentosia*. Of them, *S. transversa* is particularly close to *S. praecursor* (Stainbrook) which comes from the Box Member of the Percha Formation, New Mexico. Poole et al. (1967) assign the member a Famennian (to V, to VI) age.

Well authenticated species of *Mesoplica? hillae* occur in England, France, Germany, and Morocco only in late

Devonian (Famennian, to VI) strata. In USSR, species that Muir-Wood and Cooper (1960) assigned to the genus occur in Kazakhstan [*Sulcifer* Beds, ?*Platyclymenia* Zone (to III, to IV)]; other dubious species occur in the Abishevski Zone, Kusnetz Basin (to VI), and in the north Vostok region (Alekseeva, 1967). *Mesoplica? hillae* is decidedly more primitive, and probably older than *M. praelonga*, the type, from the Pilton Beds (Famennian, to VI) in England. It has a bilobed cardinal process with quadrifid myophore, inconstantly developed ?dental sockets, an alveolus, and fine brevisseptum in the brachial valve. The upper limit of its range is the *S. transversa* Zone, and this can be regarded as pre Famennian (to VI).

The evidence from *Spinulicosta*, *Sentosia*, and *Mesoplica* supports a Famennian (to V) age for the two zones.

#### *Sentosia minuta* and *S. profunda* Zones

The combined productoid assemblage of these zones in the Star and Yarrol Basins is *Spinulicosta dotswoodae* sp. nov., *Strophoproductus rugosus* sp. nov., *Acanthatia fragilis* sp. nov., *Whidbornella (Dotswoodia) wyatti* subgen. et sp. nov., *Mesoplica?* sp., *Sentosia profunda* sp. nov., *S. minuta* sp. nov., and *S. minuta deari* subsp. nov. The preponderance of toothed productellid genera over edentulous genera clearly indicates that the assemblage is older than those already discussed.

The occurrence of *Spinulicosta* in the zones has limited importance for age determination owing to its position below the upper limit of range.

*Strophoproductus rugosus* is most similar to *S. hystriculus* (Hall, 1867) which Tesmer (1967) has listed among species from the Canadaway Formation (Northeast Member) and Chadokoin Formation (Elliott and Dexter-villé Members)—Cassadagan (to II $\beta$ ).

*Acanthatia* has a very limited distribution. *A. nupera* (Stainbrook, 1947) occurs in the Box Member, Percha Formation of New Mexico (Famennian, to V - to VI); *Acanthatia* sp. occurs in the Imperial Formation of Yukon Territory and District of Mackenzie where it may have a lower Famennian age (Norris, 1967).

Goldring (1957) gave the range of *Whidbornella* in Europe and North Africa as "Upper Devonian *Wocklumeria* (VI) and *Clymenia* (V) stages (and almost certainly lower)". In Asia, the genus is known from the Famennian (to VI) Tarkansk Suite (Reteporine layer), Rudny Altai, and possibly from upper Famennian (Russian) of the Pamirs [*Productella membranacea* (Phillips); Reed (1922)]. The earliest species known is *Orthis productoides* Murchison, 1840 from Boulonnais, France, and from Germany. In this paper, it is assigned tentatively to the subgenus *Dotswoodia*, owing to the absence of spines on its brachial valve; it is certainly more similar to *W. (Dotswoodia) wyatti* than any other species. Its precise range is difficult to assess because the name *productoides* has been misapplied by various authors. In northern France (Boulonnais), it occurs typically in the upper Frasnian; in Germany, it occurs in the Velbert Beds (Paul, 1939) of the Rhenish Massif (Famennian, to II - to V; Erben and Zagora, 1967). Goldring (1957, p. 215) noted that it does not range above the Angertal Beds in Bergisches Land (*Clymenia*, to V).

The presence of *Mesoplica? hillae* in the zones is not of great significance; the upper limit of its range is in the



succeeding *S. transversa* Zone, and even there it is more primitive than typical *M. praelonga* of Famennian (to VI) age. By stratigraphic superposition, species of *Sentosia* in the *S. profunda* and *S. minuta* Zones are clearly older than those in the *S. transversa* and *S. plicata* Zones which have been shown already to correlate with the oldest species known in North America (Famennian, to V). *Sentosia* in the USSR (Armenia, Rudny Altai, Kusnetz Basin) is even younger (Famennian, to VI). The genus is thought to have evolved from *Agramatia* Sokolskaja by the loss of interareas and dentition. Muir-Wood and Cooper (1960, p. 148-9) gave the occurrence of *Agramatia* as Eletz Beds (Famennian, to II), Russian Platform, USSR, and Upper Devonian (Chemung) of West Virginia. These relationships suggest a Famennian age, younger than *Cheiloceras* (to II) and older than *Clymenia* (to V); however, it must be remembered that the basic premise that *Agramatia* is the progenitor of *Sentosia* is open to question.

The synthesis of these pieces of evidence relating to age is difficult, and the result imprecise. The interval of overlap of ranges attributed to the species must be relied upon, and that is Famennian (to III - to V) when the anomalous evidence from *Strophopproductus rugosus* is eliminated. As a Famennian (to V) age has been confidently assigned to the overlying pair of zones, one must favour a Famennian (to III - to IV) age for the lower pair of zones.

The age determinations made in the foregoing section are in agreement with the upper Famennian age suggested by Dear (1968, p. 7) for the total fauna of the Milkman Creek, South Kariboe, and Denny Gully Members of the Dawes Range Formation, Yarrol Basin (to which the *Sentosia profunda*, *S. minuta*, *S. transversa*, and *S. plicata* Zones correspond).

The fauna of *Morganella maxwelli* gen. et sp. nov. and *Bispinoproductus?* sp. in the base of the Boulder Creek Grit at Mt. Morgan was correlated in an earlier section with the *Cyrtiopsis* aff. *murchisonianus* Fauna of the Langtry Gully Member, Dawes Range Formation. Dear (1968) suggested a lower, or early upper Famennian age for the latter. Unfortunately, the two productoids do not improve the precision of that determination. *Morganella maxwelli* is thought to be most closely related to *Productella onusta* Hall, 1867 which was described from beds at Conewango, Napoli, and New Albion, Cattaraugus County, New York. It probably comes from the Bradfordian Conewango Group of Famennian (to III - to V) age. *Bispinoproductus?* sp. is represented by a single brachial valve, and no great reliance should be placed on it. *B. varispinosus* Stainbrook, 1947, which has an analogous brachial valve, comes from the Box Member of the Percha Formation, New Mexico (Famennian, to V - to VI); however, closely related *Leioproductus* ranges through most of the Famennian (to II - to V?).

### SYSTEMATIC PALAEONTOLOGY

Suborder PRODUCTOIDEA Maillieux, 1940

Superfamily STROPHALOSIACEA Schuchert, 1913

Family STROPHALOSIIDAE Schuchert, 1913

Subfamily STROPHALOSIINAE Schuchert, 1913,  
emend. Brunton, 1966

Genus AUSTRALOSIA gen. nov.

Type Species: *Australosia starensis* gen. et sp. nov.

**Diagnosis:** Shells small; outline subcircular to transversely quadrate; profile strongly concavo-convex, or frequently, as when the area of ventral cementation is large, flattened and partly deformed on the visceral disc, and anteriorly geniculated with a short trail; ornament of pedicle valve comprising narrow flexuous rugae posteriorly, coarse bifurcated costae anteriorly, and erect, coarse spines in a row close to the cardinal margin, and scattered about the margins of the visceral region and on the trail; ventral interarea moderately low, orthocline, extending full hinge width; delthyrium very narrow, triangular, and closed by an arched pseudodeltidium; dorsal interarea hypercline, almost as high as the ventral; no chilidium; teeth not seen; umbonal callus or 'ventral process' regularly present; ventral diductor scars smooth, elongate drop-shaped; cardinal process small, U-shaped with well separated primary lobes; socket plates strong, almost parallel to the hinge; sockets elongate, deep; median septum obscure, highest anteriorly; brachial ridges elevated, curving widely close to the margins of the visceral region.

**Remarks:** The new genus *Australosia* is a typical member of the family Strophalosiidae Schuchert, 1913 in possessing teeth and sockets, well developed interareas with the delthyrium covered by a convex pseudodeltidium, a large cicatrix indicating ventral attachment by cementation of the beak and frequently much of the visceral region throughout life, a bilobed cardinal process, and widely curving brachial ridges or impressions. The only character which might suggest affinity to another family, namely the Productellidae, is the divergent condition of the cardinal process lobes; however, the weight of evidence supports the strophalosiid assignment.

*Australosia* appears to be most closely related to the upper Middle Devonian genus *Devonalosia* Muir-Wood and Cooper, 1960, although readily distinguishable from it in certain ways. The type species of *Devonalosia* is *D. wrightorum* Muir-Wood and Cooper, 1960 and comparison will be made with that species in particular. The resemblance of these genera is greatest in respect to shell shape, the development of interareas, the lack of a chilidium, the disposition of body spines, and internally, in the elongate ventral diductor scars, and widely curving brachial impressions. The characters that distinguish *Australosia* from *Devonalosia* are the development of narrow, but sharp, flexuous rugae and coarse bifurcating costae on both valves, and internally, the constant possession of an umbonal callus, the U-shaped cardinal process with well separated primary lobes, the strong elongate socket plates (and sockets) which lie almost parallel to the hinge, and the obscure anteriorly elevated median septum.

The Permian genus *Costellaria* Muir-Wood and Cooper (1960) is probably a modified strophalosiid. It has an umbonal cicatrix with posterior coarse anchoring? spines, and elsewhere an ornament comprising fine costellae developed in two orders, narrow close rugae, and short prostrate spines. Its cardinal process is widely bilobed, and like that of *Australosia* is productacean in appearance. The shell is distinguished from *Australosia* by its lack of dentition, and by the absence of an interarea on



the brachial valve. Development from *Australosia* is a possibility, but insufficient is known of its internal characters to allow much comment.

The only other similar costate strophalosiaceans are the Permian genera *Chonosteges* Muir-Wood and Cooper, 1960, *Strophalosiina* Licharew, 1935, and *Urushtenia* Licharew, 1935, which have been grouped as the aulostegid subfamily Chonosteginae Muir-Wood and Cooper, 1960. Of these genera, *Chonosteges* has in addition to its costation, a shape very similar to that of *Australosia*; however, it has characters that distinguish it, and as presently understood, remove it from close association with the Strophalosiidae. In *Chonosteges*, the brachial valve lacks an interarea, and a marginal rim bears spines and funnel-like protuberances; internally, teeth and sockets are not developed, the myophore of the cardinal process is elevated on a pronounced shaft and its primary lobes are in contact, an alveolus occurs at its base, and brachial ridges are short and markedly recurved. The classification of Muir-Wood and Cooper (1960) carries with it the implication that the Chonosteginae developed from an aulostegid ancestor; this is supported by the lack of dentition and the development of an alveolus in front of the elevated cardinal process in *Chonosteges*. An alternative, independent evolutionary path from a strophalosiid progenitor, namely *Australosia*, must be considered, but seems less likely in view of the great differences in internal morphology. The writer regards *Chonosteges* as a partial external homeomorph of *Australosia*. As presently understood *Australosia* is monotypic and confined to strata of latest Devonian (to VI) age.

*Australosia starensis* gen. et-sp. nov.

Pl. 1, figs 1-19

**Material:** Holotype, F11324 G.S.Q.; paratypes, F4101, 4105-6, 11320, 11328, 11330-1, 11333, 11337 G.S.Q.; figured specimens, F4107, 11322-3, 11325-6, 11335-6, 11359, 11561 G.S.Q.; about thirty other specimens. All from W77G.S.Q., Star Beds. *Semiproductus etheridgei* Zone.

**Diagnosis:** As for genus.

**Description:**

(a) Exterior. The shells are small, and the largest (the holotype) is 6.3 mm in length, 8.4 mm in width. They are subcircular to transversely quadrate in outline, and deeply concavo-convex. The body cavity is narrow.

All pedicle valves have a cicatrix of attachment. In some it is confined to the area about the small umbo, but in most, much of the visceral area of the valve was cemented. This fixed mode of life influenced shell shape very considerably. Outline varies from subcircular or transversely ovate in incompletely cemented individuals to strongly transverse and quadrate in those which are more completely fixed. Convexity varies in a similar way. In longitudinal profile, umbonally attached valves are globose and have no sharp changes in curvature; strongly cemented valves are flattened on the visceral disc which is then separated from a trail of short to moderate length by a sharp geniculation. In transverse profile, the venter is flat to moderately convex; the flanks are steep. Small triangular auriculations occur on globose valves. The cardinal extremities are right-angled, or more often

acute; greatest width is at the midlength or anteriorly to it. The interarea is of moderate height, orthocline, and the full width of the hinge. The delthyrium is closed by a low, narrow, arched pseudodeltidium.

The valve is ornamented by rugae, costae, and spines. Juvenile growth stages are ornamented by close irregular rugae, but in many valves this is obscured by the cicatrix. At a length of 2 mm, irregular, flexuous costae develop and quickly become relatively coarse. They bifurcate on the trail frequently, and in this region number 4 or 5 per 2 mm. Spines are undifferentiated for size and are relatively large at maturity. They occur in a row close to the cardinal margin, and scattered distantly over the visceral disc and trail. The body spines arise from the crests of rugae or costae, and where the cicatrix occupies the entire visceral area, they form a pronounced fringe about it. The bases of spines near the cardinal margin are directed posteriorly or postero-laterally almost in the plane of the commissure; those on the body of the valve are erect or sub-erect and anteriorly or antero-laterally directed. It is not known whether they had anchoring or clasping adaptation.

The brachial valve is quite deeply concave and follows the contour of the pedicle valve closely. Consequently, some valves are evenly curved in profile, but most have a flat visceral area separated from a trail by a pronounced geniculation. The interarea is usually almost as high as that of the pedicle valve, and the notothyrium is filled by the cardinal process. The valve is finely and irregularly rugose over most of the visceral area; costate at the margins of the visceral area and on the trail. There are no spines.

(b) Interior. Teeth are not exposed on any of the pedicle valves. A small callus or 'ventral process' is regularly developed in the umbo and is continued anteriorly as a minute median ridge less than 0.5 mm in length. From the callus, elongate drop-shaped diductor muscle scars extend anterolaterally for one third of the length of the valve. They are smooth and often slightly depressed in secondary shell thickening. Adductor scars are sited postero-medially; they are elongate-oval in outline, slightly elevated, and smooth. The internal surface, except for the areas of muscle attachment, is sharply papillose like a chonetoid.

In the brachial valve, the cardinal process is relatively large, bilobate, and directed ventrally or a little postero-ventrally. Primary lobes are long, divergent, and separate to their base. Incisions for emplacement of diductor bases on the posterior surfaces of the lobes are fine and very shallow. Dental sockets are elongated laterally. They are localized between the hinge margin and strong socket plates which themselves buttress the cardinal process laterally. An extremely fine median ridge arises at the base of the cardinal process and rises a little to its extremity at the midlength. The adductor scars are not clearly delimited, although it is clear that they have an irregular undulating surface. Strong elevated brachial ridges curve widely from the adductor scars close to the margin of the visceral disc before turning inward and posteriorly toward the front of the median ridge. The area enclosed by them is sharply papillose, except for the muscle scars. Minute endospines occur at the anterior



margin of the visceral disc, and nodelike projections occur on the brachial ridges postero-laterally.

*Dimensions (mm):*

|                                 | length | width |
|---------------------------------|--------|-------|
| F11324, holotype                | 6.3    | 8.4   |
| F4101, paratype, pedicle valve  | 4.6    | 6.9   |
| F11331, paratype, pedicle valve | 6.5    | 6.9   |

*Remarks:* *Australosia starensis* occurs at two localities W77 G.S.Q. and L1058 G.S.Q. which are representative of the same horizon in the Star Beds. The localities are in gully tributaries of Horse Creek on Star Station and are little more than a quarter of a mile apart. Specimens are preserved in a non-calcareous brown and greenish-brown marine mudstone, and are associated with a diverse brachiopod fauna and plant remains. They have not been current sorted, and at least 30 per cent have articulated valves. All growth stages are represented.

Like other strophalosiaceans, *Australosia starensis* was attached throughout life by ventral cementation to a solid substrate. All pedicle valves have a large cicatrix, but although many are attached to 'twigs' of an indeterminate ?prefern, to trunk sections of the lycopod *Leptophloeum australe* (McCoy), and to large *Semiproductus* shells, many other valves are free. It is the writer's opinion that they were attached to plant material that decayed and liberated them before preservation. Specimens attached to plant material may have drifted or floated about and had a partly planktonic existence.

Superfamily PRODUCTACEA Waagen, 1883

Family PRODUCTELLIDAE Schuchert and Le Vene, 1929

Subfamily PRODUCTELLINAE Schuchert and Le Vene, 1929

Genus SPINULICOSTA Nalivkin, 1937, emend. Muir-Wood and Cooper, 1960

1937 *Spinulicosta* Nalivkin, p. 49, 140.

1960 *Spinulicosta* Nalivkin; Muir-Wood and Cooper, p. 153.

*Type species:* *Productella spinulicosta* Hall, 1857, by original designation of Nalivkin (1937, p. 49).

*Diagnosis:* See Muir-Wood and Cooper (1960, p. 153).

*Remarks:* The species described herein as *Spinulicosta dotswoodae* sp. nov. is remarkably similar in most of its characters to the type species, *S. spinulicosta* (Hall) from the Hamilton Group of New York. The two main differences are:

1. The possession of a well defined, slightly uneven row of coarse erect spines that spring from an elevated median costa on the pedicle valve.
2. The development of more continuous costation on the pedicle valve.

The erect comb of spines on the pedicle valve appears to represent an important adaptation for improved anchoring in particularly soft bottom substrata. In relation to taxonomy, the attitude is adopted that the development or adaptation of spines to a specific stabilizing function, unassociated with other recognizable evolutionary change, is of specific rather than generic importance—

though it is recognized that other workers may regard the same character as distinctive of a valid subgenus within *Spinulicosta*. *Spinulicosta stainbrooki* Crickmay, 1960 from the Middle Devonian of Canada is the only other species to bear the median row of erect spines. Certain late Devonian (Famennian, to VI) and early Carboniferous (Tournaisian) productoids such as *Productus niger* Gosselet, 1888 and *Productus bassus* Vaughan, 1905, that are associated tentatively with *Avonia* Thomas, are closely similar in form to the type of *Spinulicosta*; indeed, it can reasonably be interpreted that they evolved from one of its species primarily by the loss of dentition and interareas. It is noteworthy that Paeckelmann (1931) described a species, *Productus (Avonia) schindewolfi* from the Tournaisian Crinoidenkalken at Bleihutte, that appears, from what little is known of it, to bear the same relationship to *Productus niger* that *Spinulicosta dotswoodae* bears to *S. spinulicosta*, i.e. almost complete analogy except for the prominent row of erect spines set on an elevated median costa. The rare appearance of this spine pattern in species from Middle Devonian, late Upper Devonian, and Lower Carboniferous strata leads the writer to suggest that each arose independently from the same evolving stock in response to particular environmental conditions.

The productellid *Praewaagenoconcha* Sokolskaja, 1948 from the Upper Devonian (Famennian) of USSR has a shell shape like that of *Spinulicosta*, and a prominent median row of coarse erect spines. It is distinguished from *Spinulicosta*, and specifically from *S. dotswoodae*, by its spinose but non-costate pedicle valve, and finely spinose brachial valve, and internally by the conjunct primary lobes of the cardinal process.

*Distribution:* Cosmopolitan, lower Middle Devonian (Onondaga Limestone; Muir-Wood and Cooper, 1960, p. 48) to late Devonian, Famennian (to V); I know of no authenticated species from the latest Famennian (to VI), but it is possible that *Avonia proteus* Veevers, 1959(a) could prove to be such an example. It comes from the Fairfield Beds, Canning Basin, Western Australia.

*Spinulicosta dotswoodae* sp. nov.

Pl. 1, fig. 20; pl. 2, figs 1-24

1967 '*Avonia*' sp.; Hill, Playford, and Woods, p. d26, pl. D13, fig. 8.

*Material:* Holotype, F11292 G.S.Q. from L367; paratypes, F10505-6, 11310 G.S.Q. from L367, F11302-4, 11307-8, 11315, 11572, 3710 G.S.Q. from W100; figured specimens, F10504, 11291, 11293-8, 11306, 11309, 11311-2 G.S.Q.; more than twenty other specimens from L367. All specimens come from the lower part of the upper (mudstone) unit in the Myrtlevale Beds. *Sentosia profunda* Zone.

*Diagnosis:* *Spinulicosta* with well developed costation; coarse erect spines in an uneven, and rarely double row along an elevated median costa; interareas rarely developed; bilobate cardinal process with narrow widely divergent lobes.

*Description:*

(a) Exterior. These are small, nearly equidimensional, quadrate shells with a globose pedicle valve and deeply concave brachial valve. Their body cavity is narrow.



The pedicle valve is strongly and evenly curved in both longitudinal and transverse profile. The umbo is small and projects a little beyond the hinge; the umbonal angle is wide, and the umbonal slopes steep. The auriculations are small and convex. Cardinal extremities are slightly obtuse, nearly right-angled. The maximum width is usually at the midlength. A short, extremely narrow interarea is visible in the vicinity of the umbo on F11315, but an interarea cannot be distinguished on other valves. The valve is ornamented by spines, spine ridges, costae, rugae, and lines of growth.

Three categories of spines are developed:

(1) A single row of spines occurs on each side of the umbo close to the hinge margin, five per side. The innermost, seen on juveniles (F11303) curve medially in the plane of the commissure. Those nearer the extremities are directed posteriorly at right-angles to the hinge margin. They are similar in size to body spines.

(2) Body spines are erect in juveniles and have a weak concentric arrangement (rarely strong). Toward maturity, they are suberect and anteriorly directed on the venter, erect and laterally directed on the flanks. They arise from spine ridges or from the crest-line of costae.

(3) Erect spines of greater diameter than other body spines occur in an uneven row, and rarely two rows, along the midline of the valve. They arise from a median costa broader and higher than all others.

Spine ridges independent of costae occur within a distance of 3 to 7 mm of the umbo. Further anteriorly, the valve is moderately strongly, but irregularly, costate. Bifurcation of costae is infrequent. The median costa is always a little wider and higher than all others. Rugae occur only on the auriculations; lines of growth are clearly visible over the entire valve.

The brachial valve is deeply concave. In most, the concavity is even, but others have a gently concave visceral area separated from a trail of moderate length by a broad geniculation. The concave auriculations are delimited by rounded radial folds. The cardinal margin is upturned. The ornament comprises concentric lines of growth and radially arranged elongate pits or dimples which increase in length anteriorly and laterally. Obscure rugae occur on the auriculations of some valves. Spines are absent.

(b) Interior. In the pedicle valve, small strong teeth are supported by short, low, laterally directed ridges of thickening. A median ridge less than 0.5 mm in length always occurs in the umbo. The radially striate adductor scars are small, and occupy a narrow median depressed area. Areas presumed to be diductor attachment scars are narrowly triangular in outline, smooth surfaced, and slightly elevated. The hollow spines of this productoid communicate with the interior of the valve through short, anteriorly directed tubes which are most noticeable in the unthickened posterior half of the valve.

The brachial valve has a strongly bilobed cardinal process which projects posteriorly in the plane of the commissure. The narrow, distally widely divergent lobes are incised for emplacement of the diductor bases dorsally. Well developed dental sockets occur between the hinge margin and short socket ridges which diverge laterally from the base of the cardinal process. A fine

low median ridge, or brevisseptum, extends from a small deep alveolus in front of the cardinal process to the midlength. The elongate-triangular adductor impressions are obscure. A series of nodes near the hinge margin of these valves probably functioned like cardinal ridges to completely seal the valves posteriorly. The external ornament is reflected weakly on the inner surface, and fine endospines occur anteriorly and laterally to the visceral area.

*Dimensions (mm):*

|                                 | length | width |
|---------------------------------|--------|-------|
| F11292, holotype, pedicle valve | 11.2   | 12.3  |
| F11310, paratype, pedicle valve | 10.5   | 11.0  |
| F3710, paratype, brachial valve | 7.7    | 8.8   |

*Remarks:* *Spinulicosta dotswoodae* sp. nov. occurs at almost all stratigraphic levels in the upper, essentially mudstone unit of the Myrtlevale Beds, and in equivalent strata in the Star Beds. In the Geological Survey collections it has been recognized in collections from the localities W87, W93, W98, W100, W101, W102, L233, L357, L358, L367 and L1043 G.S.Q.; preservation is in mudstone at each of the localities except L233 where the shells occur sparsely in a fine calcareous and micaceous sandstone. The species is described from W100 and L367, which are both representative of a siliceous, very fossiliferous siltstone and mudstone interval, the *Sentosia profunda* Zone, at the base of the unit about the southeast and south margins of the Star Basin. At W100, the shells occur in a rich brachiopod-molluscan fauna, and disarticulated valves representing all growth stages occur in equal proportions; thus, some current washing is possible but little sorting has occurred. At L367, *Spinulicosta* is represented almost wholly by adult pedicle valves and occurs with disarticulated *Cyrtospirifer*.

Spines on the pedicle valve of the species include very long, anteriorly and laterally directed, arched spines that arise from the costae, and coarser and possibly longer erect spines of the median 'comb'. They are hollow, and have short calcified continuations that are directed anteriorly and lie close to the inner surface of the valve. These carbonate tubes presumably allowed caecae or filaments from the mantle margin to continue the deposition of calcite at the extremity of spines for a period after the mantle margin had extended beyond the original point of entry. This permitted growth of unusually long spines. Those on the body probably reduced the rate of settling in a fluid mud by increasing the relative area over which the weight of the shell was distributed. The vertical median comb would have helped maintain normal orientation, and with partial burial of the valve, stabilized against mild current drift. More considerable scour of beds would cause these globose shells to roll or tumble along despite their spines; the dead would be disarticulated and the separate valves sorted according to their clearly differing hydrodynamic properties. The well sorted fauna at L367 is undoubtedly the result of such current reworking of a shell bed.

*Spinulicosta stainbrookii* Crickmay, 1960 is the only other species of the genus to have developed an erect median row of spines on the pedicle valve. It comes from upper Middle Devonian limestone at Township 122, Slave River, Canada. From *S. dotswoodae*, it differs in its



much greater size, its more distinct rugae in the umbonal region, its stronger costation, the presence of a spine patch on each auriculation, and internally by the much less divergent primary lobes of the cardinal process. *Avonia proteus* Veevers, 1959(a) from the late Devonian (to VI) Fairfield Beds, Canning Basin, Western Australia was shown to have dental sockets by Veevers (*op. cit.*, text fig. 44), and for this reason may be assignable to *Spinulicosta*. A representative collection of the species held by the University of Queensland was examined, but all shells had their valves joined and the internal characters could not be seen. With respect to *S. dotswoodae* sp. nov., it is larger, the umbonal region is more strongly incurved, the outline is proportionately narrower, and there is no strong median costa and row of coarse erect spines.

Genus STROPHOPRODUCTUS Nalivkin, 1937, emend.

Muir-Wood and Cooper, 1960

1937 *Strophopproductus* Nalivkin; p. 46, 53.

1960 *Strophopproductus* Nalivkin; Muir-Wood and Cooper, p. 155, pl. 34, figs 1-4.

*Type species: Productella hystricula* Hall, 1867; by original designation of Nalivkin (1937).

*Diagnosis:* See Muir-Wood and Cooper (1960, p. 155).

*Remarks:* The species described below belongs with a group of productellid species that are assigned to the genera *Strophopproductus* Nalivkin, 1937, *Orbinaria* Muir-Wood and Cooper, 1960, and *Chonetipustula* Paeckelmann, 1931. Species in the group are characterized by: outline suborbicular to semicircular; interareas narrow, without pseudodeltidium and chilidium; ornament rugose or rugose and lamellose, long fine spines on the pedicle valve, rare on the brachial valve; cardinal process bilobate; adductor scars not dendritic. *Strophopproductus*, type species *Productella hystricula* Hall, 1867, occurs in the Upper Devonian (Canadaway Stage) of New York; *Orbinaria*, type species *Productella pyxidata* Hall, 1858, occurs in the late Upper Devonian (Louisiana Limestone) of Missouri and Iowa; *Chonetipustula*, type species *Productus plicatus* Sarres, 1857 (emended Kayser, 1882), occurs in the Lower Carboniferous (Viséan Stage) in Europe. All are here regarded as members of the subfamily Productellinae Schuchert and Le Vene, 1929.

In species of this group, internal structure is the best guide to the level of evolutionary development with respect to the entire stock. External morphology differs in detail and is useful for the discrimination of species and genera, but not for assessment of the hierarchical position, or degree of advancement, of a species within the stock. Trends that occur in the group parallel those influencing practically all productellids:

(1) Obsolescence in dentition, reflected in the loss of distinct socket plates, and the excavation of shallow sockets in the hinge margin.

(2) Reduction in the degree of separation, divergence, and elevation of the primary lobes of the cardinal process. The end product in this line is a sessile dorsally quadrifid process.

(3) Loss of the alveolus.

(4) Modification of the brevisseptum toward a robust, sometimes specialized median septum.

With respect to these criteria, the species described herein is relatively primitive. It is assigned to *Strophopproductus* because its internal morphology and external form are analogous to those of *S. hystriculus*; however, differences in ornament do occur. According to Muir-Wood and Cooper (1960, p. 155), the type has a lamellose and rugose pedicle valve with prostrate spines in one or two rows at the hinge, in two curved rows on the flanks, and scattered on spine ridges on the body, and a rugose brachial valve with spines. The pedicle valve of *Strophopproductus rugosus* sp. nov. is not lamellose, and has a distinctive spine pattern. Posteriorly directed, medially curved spines occur in a single row at the hinge margin, and undifferentiated prostrate and suberect spines arise from short spine ridges on the body. Fine spines occur only rarely on the brachial valve.

*Orbinaria pyxidata* (Hall) is distinguished from *S. rugosus* externally by its greater size, more convex ventral profile, less prominent rugae, squamose growth lamellae, and sparse spines and, internally, by the sessile bilobate cardinal process, the small hinge sockets in the hinge margin, the bulbous anteriorly forked brevisseptum, and the medially sulcate platform that replaces the alveolus. It is notable that specimens figured by Williams (1943, pl. 7) as *Productella pyxidata* Hall, from the Louisiana Limestone of Missouri, are quite as rugose as any specimen of *S. rugosus*.

*Chonetipustula plicata*, and other authenticated species of the genus, are distinguished externally by their more semicircular outline, and long straight spines, those at the hinge margin directed postero-laterally, those on the body without spine ridges, and internally by the presence of a short median septum in the pedicle valve. The interior of the brachial valve is not reliably known. Paeckelmann (1931) noted a five-lobed cardinal process, small hinge sockets, a median septum, and a pair of long ridges divergent from the base of the cardinal process.

*Strophopproductus rugosus* is the only species, other than the type, assigned to the genus.

*Distribution:* North America, Canadaway and Chadokoin Formations, New York-Cassadagan (to II $\beta$ ) (Muir-Wood and Cooper, 1960; Tesmer, 1967); Queensland, Myrtlevale Beds, Star Beds, Game Hill Beds, *Sentasia minuta* Zone, Famennian (to III - to IV).

*Strophopproductus rugosus* sp. nov.

Pl. 4, figs 1-15; pl. 6, fig. 5.

*Material:* Holotype, F11281 G.S.Q. from W81 G.S.Q., Horse Creek, Star Station; paratypes, F11487-91, 114934-G.S.Q. from L1059, Paynes Lagoon Station; figured specimens, F3958-9, 11278-80, 11282-3, G.S.Q. from W81 G.S.Q., and F3644 G.S.Q. from W94 G.S.Q.; many other specimens. *Sentasia minuta* Zone.

*Diagnosis:* Outline subcircular to semicircular; profile gently concavo-convex, rarely with a short dorsal trail; hinge less than maximum width; ventral and dorsal interareas, no pseudodeltidium or chilidium; pedicle valve



with strong concentric rugae, short spine ridges, posteriorly directed, medially curved spines in a single row at the hinge margin, prostrate or suberect spines on the body; brachial valve with rugae, elongate pits and rarely, distant fine suberect spines; teeth small; cardinal process relatively large, primary lobes well separated, widely divergent, weakly incised dorsally; socket plates short, buttressing the cardinal process; alveolus deep; brevisseptum fine, almost to midlength; adductor scars obscure, subcircular, non-dendritic.

*Description:*

(a) Exterior. The shell is small, and subcircular to semi-circular in outline. It is rather gently concavo-convex, with a narrow body cavity.

The shape of the pedicle valve varies from almost equidimensional to moderately transverse (when the length, width ratio approaches 3:4). In longitudinal and transverse profiles, the valve is evenly convex; it is without a trail. The umbo is small and the umbonal angle broad. The auriculations are of moderate size and well defined; the cardinal extremities obtuse and approaching a right-angle. Accordingly, the hinge is normally narrower than the maximum width at the midlength. The interarea is narrow, and anacline, and the delthyrium is open. The valve is ornamented by rugae, spine ridges, spines and sometimes short peripheral costae. The rugae are well developed, regular, and continuous about the front of the valve. They number eight or nine per 5 mm on the venter at maturity. The spines occur in two groupings. A row of approximately four posteriorly directed, medially arched spines occur on each side of the umbo at the hinge margin. These spines resemble clasping spines although there is no evidence of such a function. Body spines of similar size are scattered irregularly over the body of the valve and sometimes one occurs on each auriculation. They do not form concentric rows. Those developed in juvenile stages are suberect, but later spines are more nearly prostrate and arise from the extremities of short spine ridges that extend across one or two rugae. The development of erect spines without spine ridges is sometimes maintained to maturity. The spines are hollow, and those at the hinge remain open to the interior of the valve even at maturity. A fringe of spine ridges or very short costae occurs at the margin of some valves.

The brachial valve has a prominent convex umbo (protegular node). Most specimens have low even concavity; a few have a partly flattened visceral disc, a geniculation, and an extremely short trail. Auriculations are flattened and clearly delimited. The interarea is narrow and hypercline; there is no chilidium, and the base of the cardinal process fills the notothyrium. The ornament comprises close, well developed rugae, and elongate pits scattered over the visceral area. Fine, suberect spines occur rarely. The pits, like the spine bases on the pedicle valve, cross between one and three rugae. In some specimens a weak costation is present along the anterior margin. A row of deep dimples, or circular pits, occurs along the hinge margin between rugae.

(b) Interior. In the pedicle valve, teeth are small and narrow. The external ornament is strongly reflected through the thin shell. In the brachial valve, the cardinal

process is moderately large, directed posteriorly, and bilobate with well separated, divergent lobes. On the ventral surface the lobes are in contact proximally in a narrow sulcus; on the dorsal surface they bear very narrow incisions for diductor attachment. A large, deep alveolus is located immediately in front of the process. Dental sockets are shallow and narrow. They are isolated between the hinge margin and short socket plates that buttress the cardinal process. A fine low brevisseptum extends from the alveolus almost to the midlength. Adductor scars are small, subcircular, slightly elevated, and generally obscure. Strong endospines occur over the anterior half of the valve. They are longest in the median sector in front of the brevisseptum.

*Dimensions (mm):*

|                                         | length | width |
|-----------------------------------------|--------|-------|
| F11281 G.S.Q., holotype, pedicle valve  | 8.6    | 9.0   |
| F11491 G.S.Q., paratype, pedicle valve  | 10     | 14    |
| F11490 G.S.Q., paratype, brachial valve | 8.7    | 12    |

*Remarks:* In the Star Basin, *Strophopproductus rugosus* sp. nov. is found in most sections through the Myrtlevale and Star Beds, and has been collected from one locality in the Game Hill Beds. It occurs in the lower portion of the upper unit of each of these beds, and is an excellent marker fossil for the *Sentosia minuta* Zone. The species is represented in Geological Survey of Queensland collections from the registered localities: W81, W83, W87, W93, W94; L345, L539, L1057, and L1059. It is preserved in green-brown and brown mudstone, and light-brown micaceous, silty mudstone. Crushing of shells during compaction of the mud after burial is a normal occurrence. At most localities, including those from which types were obtained, several growth stages are represented in the population collected, and many of the shells have remained articulated and undisturbed. The thin shell and long slender spines of the species particularly suit the quiet bottom conditions that can be deduced from the enclosing sediment.

The only specific comparison that can be made is with *Strophopproductus hystriculus* (Hall, 1867), and that has been discussed under the generic remarks.

Genus MORGANELLA gen. nov.

*Type species: Morganella maxwelli* gen. et sp. nov.

*Diagnosis:* Shells large, transversely quadrate; umbo small, incurved, no cicatrix; profile concavo-convex; pedicle valve strongly convex, at maturity galeatiform due to a flared marginal flange; brachial valve with visceral disc gently concave, geniculated anteriorly; pedicle valve ornament of coarse spines in a single row close to the cardinal margin, a narrow median fold anteriorly, sparse peripheral radial lirae; brachial valve with shallow narrow median furrow, rugae on auriculations, no spines; teeth small; ventral diductors flabellate, divergent; cardinal process bilobed, directed postero-ventrally, the myophore posteriorly; dental sockets short, deep; no alveolus; median brevisseptum long, narrow; brachial ridges of laterally directed, distally recurved loops, and anterior shorter ridges directed postero-laterally from the extremity of the brevisseptum.



*Remarks:* From the point of view of classification, the retention of dentition, limited development of a ventral interarea and lack of dorsal interarea, the bilobate cardinal process, the narrow elongate brevisseptum, and distinctive form of the brachial ridges, are characters of great importance. They define *Morganella* nov. as a productellid, and indicate that its closest affinities are with genera of the subfamily Productellinae Schuchert and Le Vene, 1929. The form and ornamentation of the shell relate it to species normally referred to *Productella* Hall, 1867, but which are late derivatives, somewhat remote from the type species, *Productus subaculeatus* Murchison, 1840. Foremost among them is *Productella onusta* Hall, 1867 from "arenaceous and semicalcareous beds at Conewango, at Napoli, and near New-Albion, Cattaraugus county" (Hall 1867, p. 185); Bradfordian Stage. From Hall's description and figures (pl. 26, figs 29-42), the points of external resemblance appear to include the transversely quadrate outline, strongly convex ventral profile, the anteriorly geniculated brachial valve, the linear development or absence of interareas, and the rarity of body spines; of internal resemblance, the broadly flabellate, anteriorly divergent diductors, the simple bilobate cardinal process, lack of an alveolus, narrow elongate brevisseptum, and brachial ridges comprising broad lateral loops, and anterior ridges. The differences include the lack of a marginal flange and median fold (mature characters of *Morganella*), the development of cardinal spines in a small patch on the auriculations rather than in a single row, and fine body spines in concentric rows about the anterior of the pedicle valve.

Brachial ridges in *Morganella* comprise large laterally directed loops recurved at their distal extremities and narrow, postero-laterally directed ridges extending from the extremity of the brevisseptum almost to the loops. It is considered that these ridges together supported a distinctively shaped plectolophous lophophore, adnate to the brachial valve in its lateral, anterior, and medial regions. The lophophore shape interpreted for *Pugilis* by Williams and Rowell (1965, fig. 113, 2b) would probably be analogous, but that interpreted for *Plicatifera* by Brunton (1966, fig. 8) would be dissimilar. Brachial impressions that include an anterior pair of ridges occur among the productellids only in *Morganella*, *Chonopectus* Hall and Clarke, 1893, and certain late species of *Productella* such as *Productella calva* (Venjukov, 1886) as figured by Sokolskaja (1948, pl. 2, figs 4a, b; 6, 7), *Productella calva* var. *multispinosa* Sokolskaja, 1948, and *Productella onusta* Hall, 1867. The character points, with other criteria, to a common origin for *Chonopectus* and *Morganella* in *Productella*; that is, it has taxonomic importance.

Further to the similarity of brachial ridges and dentition, *Morganella* resembles *Chonopectus*, type species *Chonetes fischeri* Norwood and Pratten, 1855, particularly in the absence of spines except in the hinge region on the pedicle valve, in the transverse outline, and in the internal characteristics of the brachial valve—the bilobate cardinal process, and long low median brevisseptum. Their differences distinguish them at generic and subfamily levels. *Chonopectus* has a moderately convex ventral profile, and is never highly convex, flared peripherally, or folded (plicate) medially like *Morganella*; it has an umbonal

cicatrix; high areas occur in each valve, and both chidium and pseudodeltium are developed; the single row of major spines arises along the cardinal margin, and the trace of the spines is frequently visible across the ventral interarea; the body of the valve in all species except the dubiously assigned *Chonetes muricatus* Hall, 1867, is covered by radiating capillae which are not confined to the periphery, and sparsely developed as in *Morganella*; an alveolus occurs in the brachial valve, and a well developed septum in the pedicle valve.

The late Devonian leioproductoid genera *Leioproductus* Stainbrook, 1947 and *Galeatella* Muir-Wood and Cooper, 1960 bear a general resemblance to *Morganella* because they have highly convex, and, in the latter, galeatiform shells with sparse small body spines, a narrow median ventral plication, and dorsal furrow. They are readily distinguished as more advanced genera by their lack of dentition and interareas; by their sessile cardinal process, bilobate in *Leioproductus*, posteriorly trilobate in *Galeatella*; by the strong median septum which is divided medially in the region posterior to the anterior adductors; by the strong differentiation of anterior and posterior adductor scars (which may be coupled with the loss of dentition); and by the narrow, antero-laterally directed loops formed by the brachial ridges.

For the present, *Morganella* is regarded as monotypic; perhaps when *Productella onusta* becomes better known, it will be found to have greater affinity to *Morganella* than to *Productella*.

*Distribution:* Queensland, base of Boulder Creek Grit (of Kirkegaard *et al.*, 1969), Mt. Morgan; lower Famennian (see Biostratigraphy).

*Morganella maxwelli* gen. et sp. nov.

Pl. 3, figs 1-15

1954 *Productella* cf. *lachrymosa* (Conrad); Maxwell, p. 9, pl. 1, figs 1-4.

*Material:* Holotype, F11397 G.S.Q.; paratypes, F11391-3, 11398-9, 11402 G.S.Q., F15106 U.Q.; figured specimens, F11395-6, 11400 G.S.Q., F15104, 15107-8 U.Q. All specimens come from the base of the Boulder Creek Grit (Maxwell, 1953; Kirkegaard *et al.*, 1969) on the west bank of the Dee River, 0.75 miles upstream from its confluence with Boulder Creek, Mt. Morgan district (fig. 4). The typical locality is registered as L1036 G.S.Q., and probably is the same as L1194 U.Q., from which specimens were figured by Maxwell (1954). One other figured specimen F11409 G.S.Q. from L949 G.S.Q.

*Diagnosis:* As for genus.

*Description:*

(a) Exterior. The shell is large and transversely quadrate in outline. Profile is concavo-convex, and the body cavity is deep.

The pedicle valve has a small incurved umbo which never protrudes beyond the hinge margin. In nepionic and neanic growth stages, the valve is strongly and evenly convex in both longitudinal and transverse profiles; umbonal and lateral slopes are steep, and the auriculations are small. Near maturity, the margins of the valve



flare outward in a pronounced flange, and the overall profile is galeatiform. Moderately large flattened auricularia develop at this stage of growth. A low narrow median fold or plication can be distinguished on the anterior slopes of most valves. Cardinal extremities are obtuse or nearly right-angled; and greatest width is near, or anterior to, the midlength. The valve has a linear anacline interarea (F11399 G.S.Q.); the delthyrial region is unknown. It is austere ornamented by spines, obscure rugae, and radial lirae. The spines occur in a single row on the auricularia, close to the cardinal margin, but divergent from it. They number five on each side at maturity and are very large, and posteriorly or postero-laterally directed. They are hollow and remain in communication with the visceral cavity even at maturity. No other spines can be identified with certainty, although a few small protuberances that may be spine bases occur on the umbonal slopes of F11402 G.S.Q. Coarse rugae occur in the sulci separating umbonal slopes and the auricularia, but elsewhere they are obscure. Low irregular radial lirae are present only on the marginal flare of the valve.

The brachial valve has a gently concave visceral disc and short trail separated by a geniculation. There is no interarea. Under oblique lighting, a very shallow, narrow median depression is visible from the umbo to the anterior margin. Coarse rugae occur on the auricularia and the folds separating them from the disc. There are no spines.

(b) Interior. Teeth in the pedicle valve are small and slightly elongate. An extremely fine low median ridge occurs. Adductor scars cannot be distinguished, but the diductors are very large and reach almost to the midlength. They are flabellate, well separated anteriorly, and radially striate. Minute irregular lirae cover much of the valve interior. Mature specimens have a broad marginal zone or ridge of thickening up to 7 mm wide. It presumably allows a close fit with the brachial valve even when the external surface of the valve has flared outward.

In the brachial valve, the cardinal process is moderately large, bilobed, and posteriorly or postero-ventrally directed. The lobes are separate to their base, distally expanded, and incised on their posterior surface for diductor emplacement. Short, strong ridges diverge from its base at *ca* 30° to the hinge margin, and define narrow dental sockets. There is no alveolus, and the fine, low median ridge or brevisseptum arises 1.5-2 mm from the process and extends for two thirds the length of the disc. Adductor scars are obscure, drop shaped, slightly elevated, and about half the length of the brevisseptum. Brachial ridges are clearly defined. The posterior portions extend laterally from a position near the anterior adductors, curve anteriorly close to the margin of the disc in a broad loop, recurve sharply and terminate. The equally sharp anterior portions extend postero-laterally from the extremity of the median brevisseptum, almost to reach the posterior pair.

#### Dimensions (mm):

|                                        | length | width |
|----------------------------------------|--------|-------|
| F11397 G.S.Q., holotype, pedicle valve | 27.5   | 35    |
| F11400 G.S.Q., pedicle valve           | 26.5   | 37    |

*Remarks:* *Morganella maxwelli* sp. nov. is known only from the base of the Boulder Creek Grit at localities L1036 G.S.Q. (=L1194U.Q.), L949 G.S.Q., and L951 G.S.Q., Mt. Morgan district, Queensland; Yarrol Basin. It occurs in grey and green lithic sandstone (subgreywacke) of fine to medium grain size. The bed at the base of the formation is considerably finer grained than the overlying coarse subgreywacke and pebble conglomerate beds which are unfossiliferous. Both *Morganella* and associated *Cyrtospirifer* occur as well separated disarticulated valves, probably indicating current dispersal in the relatively high energy environment.

The species is not closely similar to any known to the writer. It is named in honour of Professor W. G. H. Maxwell who discovered and described the shell originally.

Subfamily CHONOPECTINAE Muir-Wood and Cooper, 1960

Genus WHIDBORNELLA Reed, 1943

1943 *Productella* (*Whidbornella*) Reed, p. 71.

1957 *Productella* (*Whidbornella*) Reed; Goldring, p. 215.

1960 *Whidbornella* Reed; Muir-Wood and Cooper, p. 162.

*Type species:* *Leptaena caperata* J. de C. Sowerby, 1840, by original designation of Reed (1943, p. 71).

*Diagnosis:* See Muir-Wood and Cooper, 1960, p. 162.

Subgenus DOTSWOODIA nov.

*Type species:* *Whidbornella* (*Dotswoodia*) *wyatti* subgen. et sp. nov.

*Diagnosis:* Shell large; outline transversely quadrate; umbo broad, but small; profile concavo-convex, body cavity narrow; pedicle valve moderately convex, weakly sinuate; auricularia large; brachial valve with visceral disc gently concave, weakly folded medially, at maturity geniculated, short trail; pedicle valve with sharp narrow rugae across the visceral region and auricularia, overlapping spine ridges, costae anteriorly, body spines recumbent to suberect, prominent median costa with large erect spines, auricularia with patch of suberect spines; brachial valve with close narrow rugae, elongate pits, costae anteriorly, narrow shallow median furrow or row of pits, no spines; teeth strong, buttressed laterally; sockets narrow, excavated in hinge margin; cardinal process postero-ventrally directed, weakly bifid ventrally, quadridorsally, median septum long, at maturity buttressing process, broad and usually low posteriorly, high and narrow anteriorly; dorsal adductors coarsely dendritic, undifferentiated.

*Remarks:* *Whidbornella* (*Dotswoodia*) *wyatti* subgen. et sp. nov. is here regarded as distinct from *Whidbornella caperata* (Sowerby), and other well authenticated species of the genus, yet it possesses certain rather characteristic features, mainly external, which appear to indicate a close relationship. For this reason, it is regarded as a subgenus of *Whidbornella*. *Dotswoodia* resembles *Whidbornella* (*sensu stricto*) in its large, moderately inflated transverse shell ornamented by close persistent rugae, overlapping spine ridges, anterior costae, and recumbent body spines on the pedicle valve, and in its rugae, elongate pits, and anterior costae on the brachial valve. Both have a bilobed cardinal process, and dendritic undifferentiated dorsal



adductor scars. *Dotswoodia* differs primarily in the absence of spines on the brachial valve, and possession of an elevated median costa bearing a row of well spaced coarse erect spines on the pedicle valve, and internally, in the location of narrow dental sockets in the hinge margin, and in the development at maturity of a robust, anteriorly elevated median septum which supports the cardinal process. *Whidbornella* (*Whidbornella*) has short, anterolaterally directed ridges buttressing the cardinal process lobes and isolating dental sockets proximally; and a low median brevisseptum separated from the cardinal process by an alveolus. Goldring (1957, p. 215) doubtfully included *Orthis productoides* Murchison, 1840 in *Whidbornella*, although, as he noted, it differs constantly in the absence of spines on the brachial valve; Muir-Wood and Cooper (1960, p. 163) took the same course. In this paper, the species is tentatively included in *Dotswoodia* owing to the absence of spines on the brachial valve; however, it is not known to have a median row of erect spines, and costae are not well developed. It was described originally from the upper Frasnian of Boulonnais, France, but is known also from the Velbert Beds of Germany.

*Semiproductus* Bublitschenko, 1956 is particularly similar to *Dotswoodia* and may have evolved from it by the loss of interareas and dentition.

#### *Distribution:*

##### *Whidbornella* (*Whidbornella*):

Western Europe (France, Belgium, Germany, England), Famennian (to V, to VI) (Paul 1939; Reed 1943; Goldring, 1957); Morocco, Famennian (to VI) (Termier and Termier, 1948); USSR, Rudny Altai (to VI) (Grechnishnicova, 1966); Pamirs (upper Famennian) (Reed, 1922); ?USA, Bradfordian [*Productella lachrymosa* (Conrad) of Hall (1867)]; ?China, Famennian (Muir-Wood and Cooper, 1960).

##### *Whidbornella* (*Dotswoodia*):

Queensland, Myrtlevale Beds, *Sentosia minuta* Zone, Famennian (to III - to IV); ?France (Boulonnais), upper Frasnian; ?Germany Velbert Beds, Famennian (to II - to V) (Paul, 1939; Goldring, 1957; Muir-Wood and Cooper, 1960).

##### *Whidbornella* (*Dotswoodia*) *wyatti* sp. nov.

Pl. 5, figs 1-19

*Material:* Holotype, F11477 G.S.Q., paratypes, F 11412-3, 11416, 11418, 11422, 11428, 11468-9, 11474-6, 11478-9, 11482, 11484 G.S.Q.; figured specimens, F11417, 11419, 11421, 11426, 11486 G.S.Q. All from locality L1060 G.S.Q. (and included in L1038 G.S.Q.); on Paynes Lagoon Station, Charters Towers district; Myrtlevale Beds (*Sentosia minuta* Zone).

*Diagnosis:* As for subgenus.

#### *Description:*

(a) Exterior. The shell is large, transversely quadrate in outline, and concavo-convex with a moderately shallow body cavity.

The pedicle valve is moderately to strongly convex in longitudinal profile, with greatest curvature posteriorly, a partly flattened venter, and a curved trail at maturity. In transverse profile, the venter is always flattened or medially gently sulcate, and umbonal slopes are steep. Auriculations are moderately large and flattened; cardinal extremities are obtusely angular or almost right-angled. Greatest width is usually at the midlength. The interarea is linear, and the pseudodeltidium very low and narrow. The ornament comprises rugae, spines, spine bases, and costae. The rugae are narrow, but strong, and closely cover the visceral region and auriculations. They do not persist to the trail. There are three main elements of ornament:

(1) Large erect spines occur in a single median row. They are sited along the crest of a coarse, elevated median costa that can be recognized to within 4 mm of the umbo.

(2) Recumbent to suberect spines of small diameter cover the body of the valve. They issue from the extremities of laterally overlapping spine ridges which increase in length away from the umbo. The spine ridges are radially aligned and ultimately coalesce as costae, within 10 mm of the umbo in a narrow median sector, and progressively later laterally. On the trail, the spines are distant, suberect, and located on the costae which occur 5 per 5 mm.

(3) Suberect, laterally directed spines of intermediate size occur in a patch on the auriculations. They are closely spaced along the crests of rugae. In the immature, the brachial valve is very gently concave or flattened, and deepest in the umbonal region. At maturity, a short trail (5-6 mm) is separated by a geniculation from the visceral disc. Auriculations are flattened and separated from the visceral disc by a fold. The interarea is linear, or absent. The ornament comprises close, regular, narrow rugae and elongated pits or furrows distributed like the spine ridges on the pedicle valve. Anteriorly, the pits coalesce as continuous furrows separated by costae. There are no spines. Large specimens have a gentle median fold that may be divided by a narrow, shallow furrow, or by large, elongate pits.

(b) Interior. In the pedicle valve, teeth are narrow elongate structures weakly buttressed to the valve along the fold separating the auriculations. They diverge from the hinge margin at ca 30°. The adductor muscle scars are very narrow, relatively elongate (4 mm), elevated slightly, and separated by a minute myophragm. The diductor scars are spreading, and obscurely striate.

In the brachial valve, the cardinal process is rather small and postero-ventrally directed. It is weakly sulcate medially on the ventral surface, quadrifid on the myophore, with the median muscle boundaries of the primary lobes moderately separated. Dental sockets are shallow and cut obliquely across the hinge margin close to the base of the cardinal process. Adductor muscle scars are large, broadly triangular in outline, and in thickened valves coarsely dendritic. Anterior and posterior elements are not recognizable. The median septum either buttresses the cardinal process, or arises immediately in front of it from a low pad of thickening and extends anteriorly for



three quarters of the length of the visceral disc. In mature thickened specimens, it is broad, moderately low and medially, slightly depressed posteriorly; narrow and elevated (2.0-2.5 mm) anteriorly. Brachial ridges are not recognizable. Fine endospines occur closely about the front of the visceral disc and on the trail.

*Dimensions (mm):*

|                                        | length | width |
|----------------------------------------|--------|-------|
| F11412 G.S.Q., paratype, pedicle valve | 27     | 37    |
| F11477 G.S.Q., holotype, pedicle valve | 26.7   | ca36  |
| F11468 G.S.Q., paratype, pedicle valve | 24     | 38.3  |

*Remarks:* *Whidbornella (Dotswoodia) wyatti* sp. nov. is known from a single section through the upper (essentially mudstone) unit of the Myrtlevalle Beds on Paynes Lagoon Station at the western margin of the Star Basin. It occurs at several horizons in a stratigraphic interval of 120 feet, and although the entire collection was registered originally under the locality number L1038 G.S.Q., five small collections are represented. The stratigraphically lowest collection (BLSW1) is separated from four collections (BLSW8-11) that occur in the upper 20 feet of the interval, by 100 feet of mudstone and siltstone with only *Lingula* and the lycopod *Leptophloeum australe* (McCoy) in them. The holotype comes from the field location BLSW8 (=L1060 G.S.Q.) 18 feet below the top of the 120 ft. interval (fig. 2, section C); *Sentosia minuta* Zone.

The enclosing sediments include soft, moderately calcareous, brown mudstone and siltstone, and hard, pink-brown, siliceous mudstone and siltstone which occurs interbedded (2-6 inch beds) in the mudstone. The shells are relatively undisturbed and occur sparsely in the sediment. Many pedicle valves (50 per cent) are convex-down; both articulated and disarticulated shells occur; and representatives of most growth stages are associated. The species has a median row of coarse erect spines, which may have been very long, like those of *Spinulicosta dotswoodae* sp. nov. and *Mesoplica? hillae* sp. nov. They are interpreted as representing an adaptation that improved stability against current drift on the soft muddy substrate. The very limited distribution of the species is thought to indicate a salinity or temperature control. The associated *Lingula*-plant beds are interpreted as intertidal (littoral), and the productoid beds as infralittoral, perhaps estuarine. The relationship of *W. (Dotswoodia) wyatti* to *W. (Dotswoodia?) productoides* (Murchison, 1840) has been discussed briefly in the remarks on the genus. The species is named in honour of Mr. D. H. Wyatt of the Geological Survey of Queensland, who collected the species for the first time during the mapping of the Star Basin.

Genus ACANTHATIA Muir-Wood and Cooper, 1960  
1960 *Acanthatia* Muir-Wood and Cooper, p. 158.

*Type species:* *Heteralosia nupera* Stainbrook, 1947, by original designation of Muir-Wood and Cooper (1960, p. 158).

*Diagnosis:* See Muir-Wood and Cooper (*op. cit.*).

*Remarks:* The species described herein has its analogues among the species of *Acanthatia* Muir-Wood and Cooper, 1960, *Steinhagella* Goldring, 1957, and to a less extent those of *Quadratia* Muir-Wood and Cooper, 1960.

All are grouped in the subfamily Chonopectinae Muir-Wood and Cooper, 1960. They are characterized by: shell thin; outline transversely ovate or quadrate; profile very gently concavo-convex; no trail, body cavity narrow; interareas in each valve well developed; pseudodeltidium and chilidium frequently present; spines fine on both valves; teeth and sockets small and narrow; cardinal process bilobate, ventrally directed; brevisseptum fine; adductors non-dendritic.

Of them, *Heteralosia nupera* Stainbrook, 1947, the type species of *Acanthatia*, is regarded as most nearly allied to the Queensland species. The differences that occur are important, but are considered to be insufficient to exclude the latter from *Acanthatia*. *Acanthatia fragilis* sp. nov. is distinguished from the type in the following ways: outline is slightly more transverse; the pseudodeltidium is broad and medially arched, the chilidium flat; obscure low rugae with intervening fine sharp growth lines or wrinkles occur on both valves; sockets are shallower and more oblique with respect to the hinge margin. *A. nupera* has rugae only in the hinge region on the brachial valve, and the pseudodeltidium and chilidium are narrow and strongly arched. It comes from the Percha Formation, Box Member, of New Mexico.

*A. fragilis* sp. nov. is distinguished from the type of *Steinhagella*, *Leptaena membranacea* Phillips, 1841, by: interareas higher; pseudodeltidium and chilidium complete; rugae and growth lines relatively obscure; cardinal process primary lobes more widely separated; alveolus present. *S. membranacea* has an incomplete apical pseudodeltidium, probably no chilidium, and its rugae are sharp, narrow, flexuous, and extremely persistent.

*Productus hirsutiforme* Walcott, 1884, the type of *Quadratia*, was said by Muir-Wood and Cooper (1960, p. 161) to be without pseudodeltidium or chilidium; however, Campbell (1966, p. 313) showed that an incomplete pseudodeltidium is developed on some specimens, and a thin chilidium rarely covers the base of the cardinal process. The valves have few spines, and pits occur on the brachial. Strong high marginal ridges extend laterally from the ventral umbo toward the extremities, and in the brachial valve short lateral ridges also occur. The ventral adductor scars are non-dendritic, very broad, and partly surrounded anteriorly by the diductors. In *A. fragilis*, the ventral diductors completely surround the adductor scars anteriorly.

*Distribution:* USA, New Mexico, Famennian (to V - to VI) (Muir-Wood and Cooper, 1960); Canada, Yukon and Mackenzie, ?lower Famennian (Norris, 1967); Queensland, Myrtlevalle Beds, *Sentosia minuta* Zone, Famennian (to III - to IV).

*Acanthatia fragilis* sp. nov.

Pl. 6, figs 6-15

*Material:* Holotype, F11316 G.S.Q. from L345 G.S.Q.; paratypes, F11317-9, 5164, 5168 G.S.Q. from L345; F11495, 11499-11502 G.S.Q. from L1059 G.S.Q.; figured specimen, F11492 G.S.Q. from L1059 G.S.Q.; several other registered specimens. Myrtlevalle Beds; *Sentosia minuta* Zone.



**Diagnosis:** Outline transversely quadrate; profile gently concavo-convex, no trail; umbo small, never incurved; hinge less than maximum width; ventral interarea well developed; pseudodeltidium arched medially, complete, wide; chilidium flat; pedicle valve with obscure low rugae, close sharp growth lines or wrinkles, and spines, the larger posteriorly directed in a single row at the cardinal margin, the smaller, recumbent, very fine, and distant on the body; the brachial valve with stronger growth lines and wrinkles, and fine recumbent to sub-erect spines; teeth narrow, oblique to hinge margin; ventral muscle field subcircular, diductors surrounding non-dendritic adductors anteriorly; cardinal process small, ventrally or postero-ventrally directed, widely bilobate; alveolus present; dental sockets very narrow, shallow, oblique to hinge margin; adductors ovate, non-dendritic; brevisseptum fine, less than half valve length; endospines extremely numerous, fine.

**Description:**

(a) Exterior. Shells are of moderate size for the genus, transverse, gently concavo-convex, and have a narrow body cavity.

The pedicle valve is transversely quadrate or ovate in outline, with the length 60-70 per cent of the width. The umbo is low and never incurved. Curvature is low and even in both longitudinal and transverse profiles, and the flanks spread into large flattened auriculariations. The cardinal extremities are just obtuse and the greatest width is usually at the midlength. The interarea is moderately low and orthocline; the delthyrium is closed by a broad medially arched pseudodeltidium. Ornament comprises obscure rugae, fine intervening growth lines or wrinkles, and spines. The rugae are low, and not always developed; the intervening wrinkles give a concentrically striate appearance. Spines are fine, but of two orders of size; the coarser are posteriorly directed and occur in a single slightly irregular row at the cardinal margin, the finer on the body. The latter are suberect on the flanks, nearly recumbent and arising from very short spine ridges on the venter. They are well spaced, and do not occur in concentric rows.

The brachial valve has a small convex umbo or protegular node, a gently concave or flattened visceral area, and flat auriculariations. Often there is little change in slope between auriculariations and the visceral area. The interarea is slightly narrower than the ventral, hypercline, and the chilidium is complete and flat. Ornament comprises extremely fine, close irregular growth wrinkles or lines, more prominent than those on the pedicle valve, and scattered fine recumbent spines.

(b) Interior. Teeth are narrow, bladelike, and oblique to the hinge margin. The ventral muscle field is subcircular in outline and small. Ovate or drop-shaped, non-dendritic adductor scars are separated by an extremely low myophragm; diductor muscles almost completely enclose the diductors anteriorly. Both body and hinge spines remain in communication with the interior of the valve in some mature specimens.

The brachial valve has a small ventrally or postero-ventrally directed cardinal process. The lobes are completely disjunct and each has a shallow diductor muscle pit or incision on its postero-dorsal surface. Dental

sockets are very shallow, oblique to the hinge margin, and very weakly bounded by socket ridges. An alveolus which reflects the shape of the protegular node occurs in front of the process. The brevisseptum is very fine and low, and extends almost to the midlength. Adductor scars are non-dendritic, subcircular, slightly elevated, but generally obscure. Endospines which are extremely fine and closely spaced, cover the inner surfaces of the valves except for the muscle areas.

**Dimensions (mm):**

|                                        | length | width |
|----------------------------------------|--------|-------|
| F11316 G.S.Q., holotype, pedicle valve | 8.8    | 11.5  |
| F11318 G.S.Q., paratype, pedicle valve | 14.5   | ca23  |

**Remarks:** *Acanthatia fragilis* sp. nov. is uncommon and occurs at three localities only: L343, L345, and L1059 G.S.Q., all in the lower part of the mudstone unit of the Myrtlevale Beds on the western side of the Star Basin. At each locality it is preserved in light-brown non-calcareous micaceous mudstone and flaggy siltstone of the *Sentosia minuta* Zone. Most specimens are articulated and only the earliest growth stages appear to be unrepresented in the collections. The stratigraphic position is verified by its association with *Strophoproductus* which is virtually ubiquitous in the lower part of the mudstone of the Myrtlevale Beds. Fossils at L1059 G.S.Q. represent the first relatively normal marine association above beds with only *Lingula* and the lycopod *Leptophloeum*—a probably intertidal association. The physical conditions that limited the distribution of *A. fragilis* to shallow waters on the western side of the basin are unknown, but could relate to salinity or temperature of the sea.

Its relationship with the type species *A. nupera* (Stainbrook) have been discussed in the generic remarks. In Canada, *Acanthatia* was recognized, but not described, by Norris (1967) from the Imperial Formation of the Yukon and Mackenzie districts. Campbell (1963, p. 70) described the productellid *Acanthatia? rangariensis* from the early Tournaisian Rangari Limestone and basal beds of the Namoi Formation in New South Wales. He later reassigned the species to *Quadratia* Muir-Wood and Cooper (Campbell 1966, p. 313). It differs from *A. fragilis*, externally in its more transverse outline; coarser more erect spines, especially those at the cardinal margin which are directed postero-laterally; narrower, incomplete, arched pseudodeltidium, and gently convex chilidium; internally, in the shallow alveolus and platform in front of the cardinal process, the more robust brevisseptum, and the broader dental sockets excavated entirely in the hinge margin.

Family LEIOPRODUCTIDAE Muir-Wood and Cooper, 1960 emended

**Diagnosis:** Productacea with outline quadrate; pedicle valve strongly arched, curvature spiral, trail of variable length, venter flattened or sulcate, flanks steep; brachial valve with mildly concave visceral region, usually geniculation and trail; interareas absent; ornament of rugae, spines, spine ridges, pits, and costae; dentition absent; cardinal process sessile, myophore quadrifid except in advanced forms where median muscle boundaries fuse



to give a trifold form; lateral ridges present; median septum narrow, long, frequently longitudinally divided posteriorly; dorsal anterior adductors smooth, drop-shaped; the posterior scars spreading, dendritic; brachial ridges directed antero-laterally.

*Remarks:* The family was characterized wholly by its internal morphology in the classification of Muir-Wood and Cooper (1960). In the emended form advanced here, a better distribution of genera has been sought by the introduction of shell form as an additional diagnostic character at family level, and ornamentation at subfamily level. Thus, the family Leioproductidae is interpreted as including nine genera which are separated into two subfamilies. The Leioproductinae Muir-Wood and Cooper, 1960 includes *Leioproductus*, *Bispinoproductus*, *Galeatella*, *Acanthoplecta*, *Plicatifera*, and *Mesoplica*.

The Semiproductinae subfam. nov. includes *Semiproductus*, *Rhytiophora*, and *Levipustula*. The roots of the Leioproductinae are among the genera of the Productellidae, but no specific genus can be named readily. The productellid *Whidbornella* (*Dotswoodia*) nov. has been suggested herein as the possible progenitor of *Semiproductus*, and the Semiproductinae; however, an alternative origin in the Leioproductinae cannot be eliminated or disregarded. Should the former interpretation be correct, the lines of descent of the two subfamilies are probably somewhat different and the association of these taxa becomes morphologic rather than phylogenetic.

#### Subfamily LEIOPRODUCTINAE Muir-Wood and Cooper, 1960

*Diagnosis:* Outline quadrate; umbo broad, over-arching the hinge; longitudinal profile concavo-convex; the pedicle valve highly convex, almost spirally curved, and without marked geniculation between visceral region and trail; the brachial valve with slightly concave visceral area, a geniculation, and a short trail; transverse profile showing sinuation and steep flanks; the pedicle valve frequently with a median costa or plica in the sinus; the brachial valve with a narrow, complementary median furrow; interareas absent; spines erect and usually sparse on the pedicle valve, rarely present on the brachial valve; rugae and costae variably developed; functional teeth and sockets absent; cardinal process bilobed, sessile, becoming trilobed only in advanced adults; alveolus usually weak and shallow; brevisseptum usually fine, often posteriorly enclosed by, or united with, broadly rounded ridges extending from the alveolus; anterior adductors smooth or lobate, the posterior pair slightly dendritic; lateral ridges short; brachial ridges forming narrow antero-laterally directed loops.

*Remarks:* The genera that the writer includes in the subfamily are: *Leioproductus* Stainbrook, 1947, *Bispinoproductus* Stainbrook, 1947, *Galeatella* Muir-Wood and Cooper, 1960, *Acanthoplecta* Muir-Wood and Cooper, 1960, *Plicatifera* Chao, 1927, and *Mesoplica* Reed, 1943.

#### Genus MESOPLICA Reed, 1943

1943 *Mesoplica* Reed, p. 97.

1960 *Mesoplica* Reed; Muir-Wood and Cooper, p. 175.

*Type species:* *Leptaena praelonga* J. de C. Sowerby, 1840, by original designation of Reed (1943, p. 97).

*Diagnosis:* See Muir-Wood and Cooper (1960, p. 175).

*Remarks:* *Mesoplica* is the only described member of the Leioproductinae that is clearly and regularly costate. The species described herein, and tentatively associated with *Mesoplica*, resembles *M. praelonga*, the type, in its external characteristics, but the internal morphology of the brachial valve is decidedly more primitive:

(1) Very shallow dental sockets appear to be present in two brachial valves (F11509, 11516 G.S.Q.), but their development is inconstant in the species. Whether they are functional is difficult to assess while there is no knowledge of dentition in the pedicle valve.

(2) The cardinal process is bilobed, dorsally quadrid, and the primary lobes are well separated distally.

(3) A deep circular alveolus is present.

(4) The brevisseptum is very fine, and extends less than half the length of the valve.

The interior of *M. praelonga* is not well known; however, it is without trace of dentition; the cardinal process was described as "probably trilobed" by Muir-Wood and Cooper (1960, p. 175), but their figure (pl. 44, fig. 5) appears to illustrate a dorsally quadrid process whose median muscle boundaries are elevated and in partial contact; there is no alveolus and the cardinal process is supported by a broad median septum. The interior of specimens that have been assigned to *M. praelonga* is quite as poorly known [Dehée (1929), Paeckelmann (1931)].

*Distribution:* North-western Europe (England, France, Germany), Famennian (to VI) (Whidborne, 1897; Paul, 1939; Dehée, 1929; Paeckelmann, 1931; Reed, 1943); ?Morocco, Famennian (to VI) (Termier and Termier, 1948); USSR; ?Kusnetz Basin, Abishevski (C<sub>1</sub> tab) Zone, Famennian (to VI) (Sarycheva *et al.*, 1963); Kazakhstan, Sulcifer horizon, ?*Platyclymenia* Zone (to III - to IV) (Nalivkin, 1937; Muir-Wood and Cooper, 1960); ?Queensland, *Sentosia profunda*, *S. minuta*, and *S. transversa* Zones, Famennian (to III - to IV).

#### *Mesoplica? hillae* sp. nov.

Pl. 7, figs 14-26

*Material:* Holotype, F11511 G.S.Q.; paratypes, F11507-10, 11512-17 G.S.Q., all from L358 G.S.Q.; figured specimens, F11363, 11367 G.S.Q. from L343 G.S.Q., F11360, 11370 G.S.Q. from L1043 G.S.Q.; Myrtlevale Beds, Star Basin.

*Diagnosis:* Outline transversely quadrate; ventral longitudinal profile strongly convex, long trail, no geniculation; transverse profile flattened or sulcate on the venter, steep flanks; dorsal profile slightly concave on the visceral disc, geniculate, short trail. Pedicle valve ornamented by narrow low rugae on the visceral disc; coarse slightly irregular costae, the median usually the largest, impersistent posteriorly; moderately coarse erect spines—in a sparse row at the hinge, in a patch on the



flanks, in a row on the median costa, scattered distantly on the body; brachial valve ornamented by rugae, pits, and costae, no spines. Cardinal process sessile, bilobate; alveolus deep; dental sockets very weak, inconstant; brevisseptum fine, less than half length; lateral ridges close to hinge margin, extending half distance to extremities; anterior adductors drop-shaped, smooth or lobate.

*Description:*

(a) Exterior. The shell is strongly concavo-convex, of moderate size, and probably had a shallow body cavity.

The pedicle valve is transversely quadrate in outline, with the length 65-75 per cent of the width. All valves are deformed, but it is evident that they were originally strongly convex. The umbo is broad and overarches the hinge. In longitudinal profile the visceral region is moderately convex, and there is a long trail; curvature may have been almost spiral. Most valves are fractured across the visceral area, and the anterior portion and the trail have collapsed posteriorly over the umbonal region. In transverse profile, the valve is flattened or medially sulcate across the venter. The flanks are spreading in the young, but become steep by maturity. The auriculations are moderately narrow, flattened or convex, and are separated from the umbonal slopes by a sulcus. The cardinal extremities are obtuse, but almost right-angled, and the valve has its greatest width close to the midlength. There is no interarea.

The ornament comprises rugae, costae, and spines. Rugae are low, narrow, and occur only on the visceral area; they are strongest on the umbonal slopes and auriculations. Costae appear at a valve length of 5-8 mm. Initially, only the median, which is broader and higher than the others, is continuous; those laterally to it are low and discontinuous. Across the front of the visceral area, and on the flanks and trail, all costae are strong and continuous. The median is bordered frequently by wide costal interspaces and occupies the narrow, shallow median sulcus; the laterals are of fairly constant size, and although their spacing is variable, five often occur in 5 mm.

Spines are coarse and occur in weakly defined groupings:

- (1) In a row close to the hinge margin, where they are sparse and erect and may be directed posteriorly.
- (2) In a patch on the posterior region of the flanks, and in the sulcus delimiting the auriculations. They are erect, laterally directed, and sited on the crests of rugae.
- (3) In a row on the median costa where they are erect, coarse, and moderately distant.
- (4) On the body of the valve where they are scattered sparsely on rugae and costae. They may be slightly smaller than other spines, but are erect.

The brachial valve has a slightly concave visceral area separated from a short trail by a pronounced geniculation. The hinge margin is upturned as a narrow low ridge; the auriculations are flattened or concave, and usually clearly delimited from the visceral area. The ornament comprises obscure narrow rugae, and shallow

pits on the visceral area, costae on the flanks and trail. A narrow median depression, or abnormally deep costal interspace, occurs on some valves. There are no spines.

(b) Interior. In the pedicle valve, the muscle field is obscure, and its limits uncertain. A fine low median ridge or myophragm is present posteriorly. Endospines are close, minute, and give the surface a textured appearance.

In the brachial valve, the cardinal process is small, sessile, bilobate, and posteriorly directed. On the ventral surface, the primary lobes are smooth, and separated distally; on the dorsal surface, they are separated by a deep sulcus and are incised for reception of the diductor muscle bases. Moderately strong lateral ridges extend from the base of the cardinal process, close to the hinge margin, for half the distance to the extremities. In two specimens, F11509, 11516 G.S.Q., their proximal regions appear to isolate extremely weak dental sockets cut in the hinge margin. The character is not constant. A deep circular alveolus occurs in front of the cardinal process. The brevisseptum is fine, low, tapered anteriorly, and little more than half the length of the visceral disc. Anterior adductor scars are drop-shaped, in close juxtaposition with the brevisseptum, and their surface is vaguely lobate or smooth. Posterior adductors are obscure. Coarse endospines occur about the margins of the visceral disc, and on the trail.

*Dimensions (mm):*

|                                         | length | width       |
|-----------------------------------------|--------|-------------|
| F11511 G.S.Q., holotype, brachial valve | 12.5   | 22          |
| F11515 G.S.Q., paratype, pedicle valve  | 15.5   | 25          |
|                                         |        | (flattened) |
| F11507 G.S.Q., paratype, pedicle valve  | 10.5   | 16.4        |

*Remarks:* *Mesoplica? hillae* sp. nov. most closely resembles *M. praelonga* (Sowerby) in its external characters; the differences in internal structure have been indicated in the remarks on the genus. Its slightly more primitive internal morphology of the brachial valve suggests that it may be a little older geologically than *M. praelonga*, perhaps its progenitor.

The species occurs at several localities in the upper (mudstone) interval in the Myrtlevale Beds, Star Basin. It is found in the *Sentosia profunda*, *S. minuta*, and *S. transversa* Zones, but is never common. Collection localities represented in the Geological Survey Collections are: W93 (L1051), W100, L343, L358, L1043, and L1056 G.S.Q. In the Star Basin, the species is known only from brown, non-calcareous mudstone, sometimes with siltstone interbedded. At the typical locality, L358, less than 10 per cent of valves are articulated, and the deposit may represent a reworked shell bed. Fragments of a similar form occur in association with *Sentosia minuta deari* subsp. nov. at L1994 U.Q., at the base of the South Kariboe Member, Dawes Range Formation, Cania. In this material, the costation appears to be coarser than typical, but the interior of the brachial valve is closely comparable.

The presence of a row of erect spines along an enlarged median costa in this, and other, species of *Mesoplica* is regarded as an adaptation for improved stability on soft muddy substrata, that has become a fixed character.



*Mesoplica?* sp.

Pl. 6, figs 1-4

1967 *Mesoplica* aff. *praelonga* (Sowerby); Hill, D., Playford, G., and Woods, J. T., pl. D13, figs 6-7.

1968 *Mesoplica* aff. *praelonga* (Sowerby); Dear, J. F., p. 6, table 1.

**Material:** Figured specimens, F11404 G.S.Q., from D146 G.S.Q. (=L1984 U.Q.), F27296, 27298-9 U.Q. from L2232 U.Q. Registered specimens, F27291-2, 27297 U.Q. from L2232 U.Q. All come from the Milkman Creek Member, Dawes Range Formation, Cania.

*Description:*

(a) Exterior. The original shape of the pedicle valve is difficult to interpret due to deformation, but the outline was probably quadrate or anteriorly spreading, curvature strong, either spiral or geniculated at the margin of the visceral disc. The valve has a characteristic ornament of rugae, costae, and spines. The rugae are low, narrow, and closely spaced; they are confined to the visceral area and the narrow auricularia. Costae are very fine, and 7-9 occur in 5 mm on the flanks. They arise as short broken ridges within 3 mm of the umbo, and become continuous at 5-6 mm from it, whence they maintain constant size to the front of the valve. Bifurcation is frequent, and occurs where a small spine arises from a costa. On the trail of mature specimens, a single costa frequently gives rise to three rather than two derivative costae, and of them, the median is intercalated. In the midline of the valve, a pair of particularly low, obscure costae occur typically. Anteriorly to the midlength, lateral costae converge on this median area and ultimately evanesce. The resultant ornament is most distinctive.

Two categories of spines are visible on the available specimens:

(1) Relatively coarse, erect spines that occur at intervals of 2.5-3 mm in a single median row.

(2) Extremely fine, prostrate or suberect spines that are given off from high points scattered distantly along the costae.

Neither the interior of the pedicle valve, nor the exterior of the brachial valve is known. One very poorly preserved mould of a brachial valve interior is known, F27298 U.Q. Lateral ridges which border the hinge margin are very fine and short. The median septum is extremely low and fine, and extends to the midlength of the visceral disc. The shell substance was probably thin as the ornament is clearly reflected internally; it comprises narrow bifurcating costae which are convergent partly about a median furrow, and fine close rugae, strongest on the auricularia.

The largest specimen, F11404 G.S.Q., is deformed, but its approximate dimensions are length 18 mm, width 25 mm.

**Remarks:** The species was described from Cania (Yarrol Basin) as *Mesoplica australis* by Dear (1963 MS). Subsequently, it was illustrated by Hill, Playford, and Woods (1967), and noted in faunal lists by Dear (1968),

in both instances as *Mesoplica* aff. *praelonga* (Sowerby). The species is regarded as well removed from *M. praelonga* (J. de C. Sowerby), and when sufficient material becomes available to allow complete characterization, it should be named as a new species distinguished by its unusually fine, medially convergent costae, the lack of an elevated median costa, and the fine prostrate to suberect body spines. Because the internal morphology is virtually unknown, and the external characteristics depart somewhat from those of *M. praelonga*, the type, the species is assigned only tentatively to *Mesoplica*. Dear (*op. cit.*, table 1) indicated its presence at six registered localities in the Milkman Creek Member of the Dawes Range Formation at Cania. Bulk collections held by the University of Queensland and Geological Survey of Queensland were examined. *Mesoplica?* sp is moderately represented in the collections from L2232 U.Q. and D146 (=L.1984 U.Q.); fragments were recognizable by their ornament in the collection from L2237 U.Q.; no specimens were found by the writer in collections from L1991, 2235, 2239 U.Q. The species is preserved in dark green, very fine, lithic sandstone and siltstone. It is not known in the Star Basin.

Genus *BISPINOPRODUCTUS* Stainbrook, 1947

1947 *Bispinoproductus* Stainbrook, p. 311.

1960 *Leiopproductus* Stainbrook, 1947; Muir-Wood and Cooper, p. 168.

**Type species:** *Bispinoproductus varispinosus* Stainbrook, 1947, by original designation.

**Distribution:** U.S.A., New Mexico, Percha Formation, Box Member, Famennian (to V, to VI); ?Queensland, base Boulder Creek Grit, lower Famennian.

*Bispinoproductus?* sp.

Pl. 4, fig. 16

**Material:** F11403 G.S.Q., the external mould of a brachial valve, from the base of the Boulder Creek Grit, Mt. Morgan district; L1036 G.S.Q.

**Description:** The brachial valve is transversely quadrate in outline (length 16.3 mm, width 23.5 mm), moderately concave, and has a short trail. Narrow well defined auricularia are separated from the concave visceral area by low radial folds. Ornamentation comprises rugae, dimples, and a narrow median furrow. The rugae are narrow and low, and although strongest on the auricularia, they are recognizable across the visceral area. Moderately deep circular pits, or dimples, closely cover the visceral region and trail. A narrow median sulcus arises close to the umbo, and increases in magnitude as a deep furrow across the front of the visceral area, and on the trail. Only a portion of the dorsal surface of the cardinal process is visible. It is quadrifid and slopes postero-ventrally.

**Remarks:** The specimen was collected by the writer from the same locality as the productellid *Morganella maxwelli* gen. et sp. nov. It is clearly leioproductid in its characters, and in particular resembles the brachial valve of *Bispinoproductus varispinosus* Stainbrook, 1947 from the Percha Formation (Box Member) of New Mexico (upper Famennian). Muir-Wood and Cooper (1960, p. 169) regarded *Bispinoproductus* as a subjective synonym



of *Leioproductus* Stainbrook, 1947. Certainly, the genera are closely related; but in relation to the narrow limits within which discrimination of genera was made by Muir-Wood and Cooper, the writer is unconvinced that their interpretation is correct.

*Distribution:* North America, Percha Formation, Box Member, New Mexico (Famennian to V - to VI); Queensland, base of Boulder Creek Grit, Mt. Morgan, probably lower Famennian.

Subfamily SEMIPRODUCTINAE subfam. nov.

*Diagnosis:* Outline quadrate; ventral profile strongly convex, curvature spiral, trail of variable length; venter flattened or broadly sulcate; flanks steep; dorsal profile concave, flattened disc, and in most, a geniculation, and trail; hinge less than maximum width; no interareas; pedicle valve with rugae, spines, spine ridges on visceral area, costae and spines on the trail; brachial valve with rugae and elongate pits, costae on the trail, spines in advanced forms; dentition absent; cardinal process sessile, myophore quadrifid, and in the advanced genera, trifid; lateral ridges prominent, mildly divergent from hinge; median septum very long, longitudinally divided posteriorly; dorsal anterior adductor scars drop-shaped, elevated, smooth; posterior adductors scars spreading, dendritic; brachial ridges directed antero-laterally, or nearly laterally.

*Remarks:* The subfamily includes the genera *Semiproductus* Bublitschenko, 1956, *Rhytiophora* Muir-Wood and Cooper, 1960, and *Levipustula* Maxwell, 1951. The subfamily ranges from latest Devonian (Famennian, to VI) to Upper Carboniferous (Westphalian).

*Semiproductus* was classified with the Echinoconchidae Stehli, 1954 by Sokolskaja and Likharew (1960, p. 227), with the Avoniidae Sarycheva, 1960 by Sarycheva *et al.* (1963), and with the Overtoniidae Muir-Wood and Cooper, 1960, by the authors of the family. The external form and ornamentation of the shell clearly remove it from taxonomic proximity to genera of these families.

Genus SEMIPRODUCTUS Bublitschenko, 1956

1956 *Semiproductus* Bublitschenko, p. 99.

1960 *Semiproductus* Bublitschenko; Muir-Wood and Cooper, p. 200.

1963 *Semiproductus* Bublitschenko; Sarycheva *et al.*, p. 130.

1966 *Semiproductus* Bublitschenko; Grechnishnicova, p. 109.

*Type species:* *Productus* (*Semiproductus*) *minax* Bublitschenko, 1956, by original designation.

*Diagnosis:* Outline quadrate, initially transverse, later becoming longitudinally elongate; ventral profile strongly convex; longitudinally, spirally curved, trail often long; transversely, venter flattened or mildly sulcate, flanks steep at maturity; auriculations moderately large, sharply delimited; hinge less than maximum width; dorsal profile concave; flattened or gently curved disc; geniculate,

generally short trail; no interareas; pedicle valve with partly flexuous rugae crossing visceral region, elongate overlapping spine ridges on the disc, costae on the trail, spines recumbent to suberect, in row at hinge margin, at extremities of spine ridges, sparse on costae; brachial valve with rugae and elongate pits on disc, costae on trail; no dentition; cardinal process sessile, myophore quadrifid, directed posteriorly; lateral ridges high proximally, weakly divergent from the hinge margin; median septum extremely long and narrow, low and frequently divided medially in posterior part; anterior adductors located well forward, drop-shaped, slightly elevated, smooth; posterior adductors dendritic, spreading; brachial ridges directed antero-laterally.

*Remarks:* The morphology of *Productus blairi* Miller, 1891, the type of *Rhytiophora* Muir-Wood and Cooper, 1960, is closely similar to that of *Semiproductus minax*, the type of that genus. The principal differences which distinguish the former are: the shorter trail and less elongate outline; the absence of sinuation; the presence of spines on the trail of the brachial valve; the more elongate lateral ridges; and the orientation of the brachial ridges more posteriorly, toward a lateral position. The differences appear to be sufficiently important to prevent incorporation of *Productus blairi* in *Semiproductus*, particularly as they discriminate the more advanced elements within a single evolutionary line.

The species described herein from Queensland is intermediate morphologically between *Semiproductus* and *Rhytiophora*. From *S. minax*, it differs only in its less elongate outline (shorter trail), lack of sinuation, and longer spine ridges. From *S. blairi*, it differs in the absence of spines on the brachial valve, and the shorter lateral ridges, differences which perhaps have greater taxonomic significance than those with *S. minax*.

*Semiproductus* is thought to have evolved from the productellid *Whidbornella* Reed, 1943, or its subgenus *W. (Dotswoodia)* nov., mainly by the loss of interareas and dentition. *Rhytiophora* must be regarded as its close evolutionary derivative.

*Distribution:* USSR: Rudny Altai, Tarkansk Suite, Famennian (to VI) (Grechnishnicova, 1966); Kusnetz Basin, Abishevski Zone, Famennian (to VI) (Sarycheva *et al.*, 1963); Queensland, Star Beds, *Semiproductus etheridgei* Zone, Famennian (to VI).

*Semiproductus etheridgei* sp. nov.

Pl. 8, figs 1-18; pl. 9, fig. 16

1964 *Rhytiophora* sp.; Hill, D., and Woods, J. T., pl. C7, figs 13-14.

*Material:* Holotype, F4088 G.S.Q.; paratypes, F4083-7 4089, 11407, 11543-51 G.S.Q.; figured specimens, F11405-6, 11408, 11324 G.S.Q., from W77 G.S.Q.; figured specimen F11552 G.S.Q. from L1058 G.S.Q.; Star Beds, Star Basin.

*Description:*

(a) Exterior. Shells are large, transversely quadrate in outline, and concavo-convex with a moderately deep body cavity.



The pedicle valve is strongly convex; spirally curved with a moderately long trail in longitudinal profile; flattened on the venter, and with steep flanks in transverse profile. The umbo is broad and slightly overarches the hinge; umbonal slopes are steep. The auriculations are very large and flattened, and their extremities are right-angled, or more commonly, obtusely angular. The greatest width is at the midlength. There is no interarea.

The valve is ornamented by rugae, spines, spine ridges, and sometimes costae. The rugae are sharp, narrow, slightly flexuous, and persistent across the venter on the visceral region. Spines of two categories occur.

(1) Strong spines in a single row at the cardinal margin; seven on each side of the umbo at maturity. They are posteriorly or postero-laterally directed, and lie in the plane of the commissure.

(2) Very fine, recumbent to suberect spines that cover the body of the valve, although few on the auriculations. They are moderately closely spaced, never in concentric rows, and arise from the anterior extremities of spine ridges that increase in length away from the umbo. On the trail, the ridges usually coalesce in low irregular costae (7 per 10 mm), and the spines are suberect.

The brachial valve has a gently concave, sometimes almost flat visceral disc separated from a curved trail, less than half the length of the disc, by a pronounced geniculation. The umbo is minute and convex; the umbonal region depressed. The auriculations are large and flattened. Ornament comprises sharp close rugae, and narrow elongate depressions, similar in shape to the spine ridges, on the visceral disc, rugae only on the auriculations, and irregular costae on the trail. There are no spines.

(b) Interior. Teeth are not developed in the pedicle valve. The muscle scars are flabellate, radially striate, but obscure. There is no median ridge. Minute endospines cover the surface of the trail. In the brachial valve, the cardinal process is small and sessile; the ventral surface strongly bilobate, the myophore quadrifid and directed posteriorly. The primary lobes are well separated distally, and deeply incised for the emplacement of diductor bases. The lateral ridges are particularly high proximally; they extend less than half the distance to the extremities, diverging a little from the hinge margin. The median brevisseptum is distinctive. It arises anteriorly to a smooth area in front of the cardinal process and extends for at least two thirds of the length of the disc—sometimes more. The septum is usually fine and rises to a maximum height of 1.5 mm; it may be divided by a weak median depression posteriorly. Adductor scars are extremely obscure. Anterior scars are located well forward at about the midlength of the septum; they are smooth and vaguely drop shaped. Posterior scars are spreading and dendritic. Brachial ridges were not seen. Endospines occur across the front of the disc, and on the trail.

The shell is thin.

#### Dimensions (mm):

|                                        | length | width |
|----------------------------------------|--------|-------|
| F4088 G.S.Q., holotype, pedicle valve  | 28(+)  | 37    |
| F4086 G.S.Q., paratype, brachial valve | 29     | 39    |

*Remarks:* *Semiproductus etheridgei* sp. nov. occurs in the Star Beds of the Star Basin at two localities only, W77 and L1058 G.S.Q. These localities are in tributary gullies of Horse Creek and almost certainly represent the same horizon—a closely fractured, green-brown, highly fossiliferous mudstone. At L1058, the shells have not been compressed to the same extent, normal to the commissure, as those at W77; their flattening is mainly lateral. The result is that they appear more convex, and F11552 G.S.Q. (pl. 9, fig. 16) has the elongate highly convex form typical of many *Semiproductus* species in the USSR. At the type locality juvenile shells are rare, but at L1058 they are relatively common. Valves are mostly articulated at both localities, even though associated *Laminatia* has constantly disarticulated valves. The rather long trail of the species suggests that the pedicle valve was partly, or largely, submerged in the sediment during life, and this may have contributed to stability before mild currents, and rapid burial after death. Epifauna is not very common, but the strophalosiid *Australosia* gen. nov. and a coiled polychaetid worm have been seen on the brachial valve.

*S. etheridgei* is possibly rather closely related to *S. minax*, the type, although that species is sinuate, more elongate, due to a longer trail, and has smaller spine ridges. It occurs in the brachiopod beds of the Tarkansk Suite, Rudny Altai (Grechnishnicova, 1966) which are regarded as Famennian (to VI) in age by the author.

Externally, it closely resembles *Rugauris inica* (Sarycheva, 1962) of Sarycheva, Sokolskaja, Beznosova, and Maximova (1963, pl. 15), except in its shorter trail. Text-figures of the brachial valve interior (*loc. cit.*, fig. 45) show a specialized cardinal process whose myophore is elongate, trifid, and directed dorsally. If this is a correct interpretation, the species must be regarded as more advanced than *S. etheridgei*. *R. inica* occurs in the Kusnetz Basin, Abishevski Zone, which is regarded as the basal zone of the Russian Carboniferous; that is, equivalent to Famennian (to VI) in the usage accepted herein (see International Correlation).

*Semiproductus etheridgei* from the type locality was figured as *Rhytiophora* sp. by Hill and Woods (1964) in the "Carboniferous Fossils of Queensland"; the identification was made by the writer.

#### Family SENTOSIIDAE nov.

*Diagnosis:* Productacea with outline transversely ovate, quadrate; profile evenly concavo-convex, flanks spreading, no trails; interareas absent, or linear, and on the pedicle valve only; ornament including combinations of narrow rugae sometimes lamellose, fine, normally recumbent spines on both valves, and fine spine ridges; dentition lacking; cardinal process sessile, myophore quadrifid, rarely trifid; dorsal median septum fine; lateral ridges variably developed; dorsal adductor scars smooth or lobate, rarely dendritic; brachial ridges oblique.

*Remarks:* The genera that are included in this family are *Sentosia* Muir-Wood and Cooper, 1960, *Laminatia* Muir-Wood and Cooper, 1960, *Rugauris* Muir-Wood and Cooper, 1960, *Planoproductus* Muir-Wood and Cooper, 1960, and *Stegacanthia* Muir-Wood and Cooper, 1960.



Their occurrence is late Upper Devonian and Lower Carboniferous (Mississippian). It is envisaged that they arose, or evolved, from a productellid stock whose nearest representative may be *Agramatia* Sokolskaja, 1948. One or more genera of the family are thought to have given rise to genera of the Echinoconchidae Stehli, 1954. In the classification of Muir-Wood and Cooper (1960), the genera of the Sentosiidae were variously assigned to the Leioproductidae and the Overtoniidae, mainly on their internal morphology. These families are restricted herein, and the former redefined; typically, the genera belonging to them differ greatly from the relatively broad, often flattened, trail-less shells of the sentosiid genera.

#### Genus SENTOSIA Muir-Wood and Cooper, 1960

1960 *Sentosia* Muir-Wood and Cooper, p. 196.

*Type species:* *Krotovia praecursor* Stainbrook, 1947, by original designation of Muir-Wood and Cooper, (*op. cit.*).

*Diagnosis:* See Muir-Wood and Cooper (1960, p. 196).

*Remarks:* Four new species, and two new subspecies from the late Upper Devonian of the Star and Yarrol Basins are assigned herein to *Sentosia*. Of them, one of the more advanced species *S. transversa* sp. nov. is closely similar to *S. praecursor* (Stainbrook), the type species. It is distinguished primarily by its greater size, and relatively more transverse outline at maturity. The species and subspecies are representative of specific combinations of outline, profile, ornamentation, and dorsal internal structure within a single rapidly evolving lineage. The two forms that come from the Yarrol Basin are regarded as geographic subspecies of species that characterize the Star Basin succession.

Three very simple trends are clear in the lineage, and field checking has shown that they can be applied stratigraphically with considerable confidence.

(1) Toward a relatively wide, transverse shell outline.

(2) Toward a decrease in convexity of the pedicle valve, and concavity of the brachial valve.

(3) Toward a flattened, and ultimately strongly sinuate venter.

Changes in the relative development of internal structures, particularly dorsal adductor scars, can be related directly to the curvature of the valves [*cf.* Maxwell (1954) for Permian Strophalosiidae in Queensland].

*Distribution:* USA: Iowa (English River Sandstone = *Chonopectus* Sandstone at Burlington), late Bradfordinian (to VI), *S. nummularis* (Winchell, 1863); Collinson *et al.*, 1967; New Mexico (Percha Formation, Box Member), Bradfordinian (to V - to VI) (Muir-Wood and Cooper, 1960; Poole *et al.*, 1967); USSR: Kusnetz Basin (Abishevski Zone, C<sub>1</sub><sup>tab</sup>), Famennian (to VI) (Sarycheva *et al.*, 1963); Rudny-Altai (Tarkhansk Suite), Famennian (to VI) (Grechnishnicova, 1966); ?Caucasus, Famennian (to VI) (Abramyan, 1957); Queensland (Myrtlevale and Star Beds, Dawes Range Formation—Milkman Creek and Denny Gully Members), Famennian (to III-? to VI); Western Australia (Ningbing Limestone), Famennian.

#### *Sentosia profunda* sp. nov.

Pl. 9, figs 1-13

*Material:* Holotype, F3667 G.S.Q.; paratypes, F3669, 11442, 11445-7, 11450-2, 11465 G.S.Q.; figured specimens, F11443, 11449, 11460-1 G.S.Q.; about twenty other registered specimens. All from W100 G.S.Q., Myrtlevale Beds, Star Basin.

*Diagnosis:* *Sentosia* with outline slightly transverse to transversely ovate; length, width ratio 0.75 to 0.78 at maturity; ventral profile globose, brachial profile deeply concave; anterior commissure broadly unisulcate; body spines on pedicle valve very fine, frequently in concentric bands; spine ridges minute; spines of mature brachial valves sparse, in characteristic oblique rows at the anterior margins of the auriculations, and in a peripheral zone; cardinal process with myophore in plane of commissure, lateral muscle boundaries sometimes enrolled; dorsal adductors relatively short, slightly elevated, anterior elements slightly longer than posterior, both smooth, elongate triangular, and of similar width; brachial impressions antero-laterally directed; dorsal endospines large, scattered across the width of the valve.

*Description:* The shells are of moderate size for the genus. Their outline is transversely ovate, and the length, width ratio is 0.75 to 0.78. The body cavity appears to have been moderately deep.

(a) Exterior. The pedicle valve is strongly convex, and particularly globose in the young. In longitudinal profile, curvature is even and the incurved umbo overarches the hinge. In transverse profile, curvature is also even with no perceptible flattening of the venter; flanks are steep. The umbonal region is relatively large and protuberant. Auriculations are not strictly developed until maturity; earlier a slight flattening occurs close to the hinge margin. The cardinal extremities are obtuse (110°) and the greatest width is at the midlength. An interarea is not developed.

The valve is ornamented by spines and strong growth lines. Exceedingly fine, prostrate or recumbent spines densely cover the body of the valve. Toward the front of certain specimens they occur in pronounced concentric bands and are seen to arise from minute spine ridges. Larger spines (twice the diameter of body spines) occur in a thick postero-laterally directed brush along the hinge margin.

The brachial valve is evenly and deeply concave in the visceral area, and the auriculations are better defined than those of the pedicle valve. The ornament comprises spines, pits, and prominent growth lines. In immature specimens, extremely fine, closely spaced spines arise from minute spine ridges separated by elongate pits. At maturity, the pits are vague, and the spines larger, fewer, and distinctively grouped. Two, (and distally three) oblique rows of suberect, laterally directed spines occur along the anterior margin of the auriculations. Recumbent to suberect spines of similar size are scattered in a wide marginal zone. The anterior commissure is broadly unisulcate.

(b) Interior. The pedicle valve is without teeth. Muscle scars cannot be recognized, but a very low median ridge is regularly present. Minute papillae cover the internal surface.



The brachial valve has a relatively small bilobed cardinal process. The diductor attachment surface is approximately in the plane of the commissure, and may be elevated above the hinge margin. The postero-ventral surface is bilobed. On the dorsal surface, the primary lobes are divergent in the immature; they are in close juxtaposition, though separated by a deep sulcus to their base, at maturity. Consequently, median muscle boundaries are always parallel at maturity. Some immature valves have the lateral muscle boundaries enrolled dorsally in part. Diductor attachment surfaces bear sharp growth ridges across the length of the process.

Lateral ridges extend from the base of the cardinal process for two thirds of the width, and diverge only slightly from the cardinal margin. The median septum is usually almost half the length of the valve, relatively low, narrow, and tapered anteriorly. Both anterior and posterior adductor scars are clearly delimited and slightly elevated at maturity. The anterior are 23 per cent of the length of the valve, or half the length of the septum, and in contact with it. They are narrowly triangular in outline, and smooth. The posterior are similarly smooth and triangular and equally wide, but are shorter and less elevated.

Very obscure shallow grooves trace open antero-laterally directed loops that may be homologous in function, as lophopore attachment sites, with the brachial ridges or impressions. Outside the area enclosed by these loops, very coarse endospines are scattered evenly and moderately closely across the valve, although decreasing in size laterally from the median section. Inside the loops spines are smaller and their outline is muted, perhaps by masking, undifferentiated secondary shell material.

*Dimensions (mm):*

|                                 | length | width |
|---------------------------------|--------|-------|
| F3667, holotype, brachial valve | 20     | 30.5  |
| F11445, paratype, pedicle valve | 21     | 28    |

*Remarks:* The species occurs typically at W100 G.S.Q. in a section across the Myrtlevale Beds near Moody Dam. It is the earliest *Sentosia* in the Star Basin, and occurs associated with *Spinulicosta dotswoodae* sp. nov. and rare doubtful *Mesoplica? hillae* sp. nov. It is found only about the southern and south-eastern margins of the basin in a fossiliferous, highly siliceous, grey-brown and greenish-brown siltstone and mudstone sequence at the base of the upper unit, Myrtlevale Beds; its occurrence may be controlled by restriction to a siliceous siltstone facies which seems to be equivalent to fine sandstone beds about the northern part of the basin. The siliceous siltstone with *Sentosia profunda* has also been seen in a tributary of Percy Creek, and on both limbs of a syncline in a tributary of Ten Mile Creek on Marlow Station (northern limb, L1052 G.S.Q.).

At the type locality, all valves are disarticulated, which is a little surprising in such a fine-grained rock. Most growth stages are represented and brachial and pedicle valves appear to be in equal proportions; that is, there is no evidence of sorting. Several brachial valves have an external epifauna of coiled polychaetid worms (*Serpula?*) and encrusting bryozoa. Internal surfaces are free of

epifauna; so that while the valves were disarticulated after death, they were buried fairly rapidly, and as concluded earlier, were not sorted.

*S. profunda* appears to have given rise to *S. transversa* sp. nov. and *S. minuta* sp. nov. independently. Their distinguishing characters are discussed later in the remarks on them.

*Sentosia profunda* occurs at L1991 U.Q., in the Milkman Creek Member of the Dawes Range Formation, Yarrol Basin. It was listed by Dear (1968, table 1) from the locality as *Sentosia* cf. sp. nov. *a*.

*Sentosia minuta* sp. nov.

Pl. 10, figs 1-11

*Material:* Holotype, F11518 G.S.Q., paratypes, F3869-70, 11438, 11519-26, 11528 G.S.Q.; all from W93 = L1051 G.S.Q., in a tributary gully of Percy Creek, Myrtlevale Beds; Famennian.

*Diagnosis:* Very small, subcircular *Sentosia*; length, width ratio 0.88-0.90; ventral profile evenly and moderately convex; dorsal profile moderately to slightly concave; no trails; on pedicle valve, body spines very fine, recumbent, issuing from spine ridges, radially disposed anteriorly, but not concentrically arranged; coarser sub-erect spines in patch on auricularations; on brachial valve, spines extremely fine, close, and constant in size; pits between spines, coalescing and separated by narrow costae—directed laterally on flanks, anteriorly in the median sector; large, deep, circular pits in rows across anterior margins of auricularations; cardinal process sessile; myophore in commissural plane or tilted slightly ventrally; primary lobes separated by deep sulcus; median muscle boundaries mildly divergent; lateral ridges high proximally, short, parallel to hinge margin; median septum high, half length of valve; dorsal adductor scars on elevated, diamond-shaped platform; anterior scars much wider and longer than the posterior, set on bevelled postero-lateral margin of the platform; spikes directed antero-laterally from posterior adductors; dorsal endospines large only in median sector.

*Description:* This is the smallest Australian species of *Sentosia*, subcircular to slightly transversely ovate in outline, and concavo-convex with a narrow body cavity.

(a) Exterior. The pedicle valve has a length, width ratio of 0.88-0.90 in undeformed specimens. The umbo is small and does not overarch the hinge. In longitudinal and transverse profiles, curvature is moderate and even; neither trail nor flattening of the venter occurs; flanks are moderately steep to spreading. The auricularations are developed best at maturity, but even then they are narrow and poorly delimited. The cardinal extremities are right-angled or slightly obtuse; greatest width is at the mid-length. There is no interarea.

The valve is ornamented by growth lines, fine, narrow rugae, spines, and spine ridges. The rugae are confined to the auricularations; growth lines are inconspicuous. Spines of two sizes occur:

(1) Extremely fine recumbent spines cover the body of the valve. They arise at the extremities of short to well developed spine ridges, and are not concentrically



arranged. Spine ridges may almost coalesce as weak fine irregular costae antero-medially.

(2) Coarser spines occur in a patch, which includes a row at the cardinal margin, on each auriculation.

They are suberect.

The brachial valve is mildly to moderately concave; deepest in the umbonal region. It is evenly curved across the visceral region in both longitudinal and transverse profiles. The auriculations are flattened but not sharply delimited. Ornamentation is weak in the umbonal region; elsewhere it comprises growth lines, pits, "costae", and spines. The pits are particularly characteristic. Across the anterior portion of the auriculations, large rather deep circular pits occur in one row proximally, and in as many as three rows distally. Elsewhere, they are close, fine, and separated by low mounds bearing body spines. In many valves the pits coalesce as fine narrow furrows separated by fine "costae". They are directed laterally on the flanks, anteriorly on the median sector of the valve (F11526). These costae on the flanks are most distinctive in being laterally, but never radially, directed. Extremely fine suberect spines of constant size closely cover the entire valve.

(b) Interior. The interior of the pedicle valve is not known.

The brachial valve has a small sessile cardinal process directed posteriorly. The ventral surface is strongly bilobed; the dorsal myophore lies in the commissural plane, or slopes slightly ventrally. Its primary lobes are separated by a deep narrow sulcus, and each is incised for diductor emplacement. Median muscle boundaries diverge mildly. Lateral ridges are high proximally, parallel and close to the hinge margin, and less than half of the width. The median septum is high and half the valve length. The adductor muscle field is characteristic of the species. It is regularly elevated on an elongate diamond-shaped platform of thickening. The anterior adductors are broadly drop-shaped, smooth or vaguely lobate, and half the length of the median septum which they border. The posterior adductors are elongate-triangular or drop-shaped, smooth, and shorter and narrower than the anterior pair. They occupy the bevelled postero-lateral margins of the platform. Short spikelike ridges of thickening extend antero-laterally from their extremities. Brachial ridges have not been recognized. Endospines are very large and anteriorly directed in a broad median sector; elsewhere fine and few.

*Dimensions (mm):*

|                                  | length | width   |
|----------------------------------|--------|---------|
| F11518, holotype, brachial valve | 9.8    | 12.3    |
| F11528, paratype, pedicle valve  | 10.5   | ca 11.0 |

*Remarks:* From *Sentosia profunda* sp. nov., its probable progenitor, *S. minuta* sp. nov. is distinguished by several characteristics:

(1) The subcircular outline at maturity (judged by the heavy secondary thickening of the dorsal muscle platform and endospines).

(2) The less concave brachial valve.

(3) The ornament: spine ridges on the pedicle valve are pronounced, never short, and disposed in concentric bands; the deep circular pits across the dorsal auriculations; and the fine dorsal body pits which coalesce as furrows separated by costae.

(4) The dorsal muscle field: its location on an elongate diamond-shaped platform of thickening; the much greater length and width of anterior adductors relative to posterior adductors; and the antero-laterally directed spikes of thickening from the extremities of posterior adductors.

From its geographic subspecies *S. minuta deari* subsp. nov., it is distinguished by:

(1) Its smaller size.

(2) Its more deeply concave brachial valve, and shallower body cavity.

(3) The dorsal ornament: rows of coarse pits across the auriculations, and laterally or anteriorly directed "costae".

(4) The short lateral ridges close, and parallel to, the cardinal margin—rather than elongate, and anteriorly divergent.

In addition to specimens from the typical locality W93 G.S.Q., *S. minuta* is represented poorly in Geological Survey Collections from W87, W94, L345, L1056, and L1059 G.S.Q. It occurs in brown and greenish-brown, non-calcareous, micaceous mudstone and siltstone, that occur in the lower part of the thick mudstone unit that comprises the upper part of the Myrtlevale Beds, Star Basin. At the typical locality, 50 per cent of the valves are disarticulated, perhaps by organic activity, as there is no evidence of current disturbance or sorting of shells. The brachiopods, and associated bivalves and pelmatozoan echinoderms, are scattered evenly through the sediment.

*Sentosia minuta deari* subsp. nov.

Pl. 10, figs 12-19

1964 *Sentosia* sp.; Hill, D., and Woods, J. T., pl. C6, figs 15-17.

1968 *Sentosia* sp. nov. *a*; Dear, J. F., p. 6, table 1.

*Material:* Holotype, F27253 U.Q.; paratypes, F27227, 27254, 27257, 27260-1, 27287 U.Q.; figured specimens, F27259, 59051-2 U.Q.; two other registered specimens, F27288-9 U.Q. All come from L1994 U.Q. = D145 G.S.Q., South Kariboe Member, Dawes Range Formation (Dear, 1968).

*Diagnosis:* Subcircular *Sentosia* of moderate size; ventral profile strongly and evenly convex; dorsal profile gently concave; no trails; pedicle valve with fine recumbent spines and short spine ridges on body, without concentric arrangement; suberect spines in a patch on auriculations; brachial valve with fine close pitting, and spines; cardinal process sessile—myophore quadrifid, directed postero-dorsally, or dorsally, primary lobes in contact or divergent; lateral ridges elongate, widely divergent from the hinge, sometimes continuous with



broad marginal ridges; median septum half valve length, bulbous at base of cardinal process, tapered anteriorly; dorsal adductors elevated, anterior pair longer and wider than the posterior; short spikelike ridges extending antero-laterally from the narrow triangular posterior adductors appear to be bases of vague, very short, oblique loops—the brachial impressions.

*Description:* The shell is of moderate size for the genus. Its outline is subcircular and the length, width ratio is variable between 0.8 and 0.9. The body cavity is deep.

(a) Exterior. The pedicle valve is globose. In longitudinal profile, curvature is even and decreases from the umbo; in transverse profile, the venter is slightly flattened, and lateral slopes are moderately steep. The umbo is broad and slightly overarches the hinge; umbonal slopes are steep. Small flattened auriculations are differentiated only as the valve nears maturity. The cardinal extremities are obliquely angular, and greatest width is at the midlength. There is no interarea. The ornament comprises very fine spines, spine ridges and rarely, distant rugae. On the body, the spines are prostrate or recumbent and arise from closely spaced, short spine ridges, but on the auriculations where spine ridges are absent, spines are suberect and occur in a postero-laterally directed brush. The spines are not concentrically arranged.

The brachial valve is gently and evenly concave and the auriculations are poorly delimited. Unfortunately, the ornament is not well known. It appears to comprise growth ridges, pits, and spines. Prominent growth ridges are confined to the auriculations. Pits are subcircular posteriorly, elongated anteriorly; they cover the entire surface. Recumbent spines can be recognized only anteriorly, but their distribution may have been much more general.

(b) Interior. The interior of the pedicle valve shows an extremely fine short myophragm, but muscle scars cannot be delimited.

In the brachial valve, the cardinal process is small and sessile; bilobate ventrally; with a quadrifid myophore directed dorsally or postero-dorsally.

Median muscle boundaries of the primary lobes may be in contact and elevated, or separated by a sulcus and divergent. Lateral ridges are very strongly developed. They extend from the base of the cardinal process diverging widely from the hinge margin, and in one valve, becoming continuous with broadly rounded marginal ridges. The median septum arises from a prominent knob of thickening at the base of the cardinal process. Posteriorly, it is broad, slightly elevated, and rounded in section; anteriorly, it tapers to a fine extremity at the midlength.

Anterior and posterior adductor elements are very clearly delimited. The anterior are drop-shaped, moderately broad, half the length of the septum, elevated, and smooth. Their medial margins are in contact with the septum. The posterior elements are shorter, narrowly triangular in outline, and antero-laterally directed. They may be indistinctly striate along their length. Spikelike prominences from their antero-lateral extremities appear to be the bases of very short, oblique brachial impressions.

The impressions are outlined by fine grooves in the form of loops, within which occur ridges of calcite parallel to the valve margin. They may represent the line of attachment of the lophophore.

The inner surface of the valve is finely papillose. The posterior margins of the cardinal ridges appear to bound shallow dental sockets proximally; but I doubt that they had this function.

*Dimensions (mm):*

|                                 | length | width  |
|---------------------------------|--------|--------|
| F27227, paratype, pedicle valve | 21     | ca23   |
| F27258, paratype, pedicle valve | 21.5   | ca22.5 |

*Remarks:* The subspecies was described originally by Dear (1963MS) as *Sentosia pristina* in an unpublished thesis submitted for the Degree of Doctor of Philosophy (University of Queensland). His primary work is recognized herein in the naming of the subspecies. *S. minuta deari* subsp. nov. occurs at the typical locality L1994 U.Q. in the South Kariboe Member, Dawes Range Formation near Cania, Yarrol Basin, as chlorite and epidote lined moulds in dark grey-green, very fine to medium-grained lithic sandstone. Dear (1968, table 1) indicated that the species (listed as *Sentosia* sp. nov. a) occurred at four other localities in the South Kariboe Member. Fossils from only one of them (L2247) are represented in the University of Queensland collection, but they do not include *Sentosia*. The means of distinction of the subspecies have been outlined in the remarks on *S. minuta* sp. nov.

Dear (1968, table 1) further indicated that a form *Sentosia* cf. sp. nov. a occurs at six localities in the stratigraphically lower Milkman Creek Member. An examination of the bulk collections at the University of Queensland was made by the writer with a mixed result;

L1984 U.Q., the collection could not be located by the writer.

L1991 U.Q. *Sentosia profunda* sp. nov.

L2229 U.Q. no productoid brachiopods.

L2232 U.Q. Two specimens doubtfully referable to *S. minuta deari* subsp. nov.

L2235 U.Q., no productoid brachiopods.

L2239 U.Q. indeterminate fragments of *Sentosia*.

*Sentosia*, which appears from photographs to have similar size, outline, and curvature of valves to that of *S. minuta deari*, occurs in Western Australia (Bonaparte Gulf Basin) in the back reef facies of the Ningbing Limestone, Jeremiah Hills; it is described as a new species by Dr. Roberts, in a publication in preparation.

*Sentosia transversa* sp. nov.

Pl. 11, figs 1-13

*Material:* Holotype F5201 G.S.Q.; paratypes, F11529-34, 11536-42 G.S.Q.; many other specimens; all from L358 G.S.Q., upper mudstone unit, Myrtlevale Beds, Star Basin.



**Diagnosis:** Large *Sentosia*; outline transversely ovate; length, width ratio at maturity 0.61; ventral profile moderately, evenly convex; venter rounded; dorsal profile slightly concave; cardinal extremities well rounded; spines on body of pedicle valve exceedingly fine and close, recumbent; spine ridges minute; much coarser suberect spines along posterior margin in a brush 4-7 spines wide; spines on brachial valve sparse, very fine, prostrate, only in a peripheral zone at maturity; fine, closely spaced, slightly elongate pits closely covering surface; cardinal process small; myophore quadrifid, directed dorsally; lateral ridges high proximally, long, diverging from the hinge at *ca* 5°; mediad septum very fine, low, half length of valve; anterior adductors drop-shaped, smooth, slightly elevated; posterior adductors obscure; large endospines across width of valve.

**Description:** The shell is large for the genus, particularly transverse at maturity, and concavo-convex with a moderately shallow body cavity.

(a) Exterior. The pedicle valve has a transversely ovate outline; the length, width ratio decreases from 0.76 at a length of 19 mm, to 0.61 at a mature length of 27 mm. The umbo is small and incurved at its extremity; the umbonal angle is close to 100°. In longitudinal profile, convexity is moderate, and curvature decreases evenly away from the umbo; geniculation and trail are absent. In transverse profile, the venter is evenly curved; flanks are spreading. The valve has a partly flattened posterior margin; clearly delimited auriculations are absent. The cardinal extremities are broadly rounded, and greatest width is at the midlength or slightly posteriorly to it. There is no interarea.

The ornament comprises concentric growth lines and spines. In most valves, the body is covered by extremely fine, very closely spaced recumbent and prostrate spines whose maximum length is 5 mm. They arise from very short delicate spine ridges which have a very limited concentric arrangement in some, a weak radial alignment in others. One valve (F11540) is only very sparsely spinose on the body, and the concentric growth lines are pronounced. A brush of much coarser suberect spines, often six or seven spines wide, invariably occurs along the posterior margin. The spines curve posteriorly or postero-ventrally, and have a maximum length of 10 mm.

The brachial valve is slightly concave, and evenly curved in both longitudinal and transverse profiles. It is flattened postero-laterally as broad auriculations which curve smoothly to the visceral region. The ornament comprises growth lines, pits, and spines. Pits are circular or slightly elongate and closely cover the entire valve. Spines are very fine, prostrate, and have been recognized only in the peripheral zone of mature valves.

(b) Interior. A fine low myophragm reaches a length of 8 mm in the pedicle valve. Very narrow, low, smooth adductor platforms border it; diductor scars are not impressed. A thin shell is suggested by the internal reflection of the ornament. The brachial valve has a small, narrow, sessile cardinal process. It is bilobed ventrally, with the lobes separated by a moderately deep sulcus or pit; quadrifid on the myophore, and primary lobes are separated by a sulcus of variable width. The myophore is

directed dorsally. Lateral ridges are very strong proximally and extend 75 per cent of the distance to the extremities. They diverge from the hinge margin at 5° for most of their length, but more strongly near the distal extremities. The median septum is characteristically extremely fine and low, and extends to the midlength. Adductor scars are usually obscure. The anterior pair are slightly elevated, smooth, drop-shaped, and less than half the length of the septum. Posterior adductors are not impressed. Coarse anteriorly directed endospines occupy a broad zone anteriorly to the adductors across the valve. Brachial ridges have not been seen.

*Dimensions (mm):*

|                                 | length | width |
|---------------------------------|--------|-------|
| F5201, holotype, pedicle valve  | 26     | ca42  |
| F11531, paratype, pedicle valve | 24     | ca39  |

**Remarks:** *Sentosia transversa* sp. nov. is a distinctive and relatively common species in the middle portion (*S. transversa* Zone) of the upper (mudstone) interval in the Myrtlevale Beds, Star Basin. In the Geological Survey Collection it is represented in material from the localities W98 and W101 G.S.Q., L358, L818, L1043, and L1061 G.S.Q. At the type locality the species is preserved in light-brown mudstone and very fine-grained sandstone; elsewhere it occurs in light-brown, sometimes grey-green, siltstone and fine and medium-grained feldspathic and lithic, variably micaceous sandstone. At L358 shells representative of most developmental stages occur rather closely packed in the beds. They are disarticulated mostly, and have been deposited convex side upward where this has been checked. Because the shells had a large surface area and low specific gravity (thin shell material), they were probably susceptible to current redistribution after death and decay of the soft parts.

The species has much in common with *S. profunda*, its likely progenitor, but can be distinguished by several characteristics: the greater size and more transverse outline at maturity (length, width ratio of 0.61, against 0.75-0.78); the less convex ventral profile, and flattened, much less concave dorsal profile; the well rounded cardinal extremities; the exceedingly small size and close, but seldom concentric, arrangement of spines and spine bases on the body of the pedicle valve; the absence of coarse spine rows across the anterior of the auriculations; the greater divergence of the long lateral ridges from the hinge margin; the extremely fine, low median septum; and the lack of dorsal posterior adductor impressions.

*Sentosia transversa caniensis* subsp. nov., which is regarded as its geographic subspecies, is distinguished by its more inflated pedicle valve which has a tendency toward flattening or very weak sulcation of the venter; by the posterior tilt of the myophore and extension of its median muscle boundaries; and by its lateral ridges which closely follow the posterior margin.

With respect to the type species, *S. praecursor* (Stainbrook, 1947), *S. transversa* is distinguished primarily by its greater size and more transverse outline at maturity. Additionally, its very sparsely spinose brachial valve, and lateral ridges that are proportionately more elongate, and



more divergent from the hinge margin, and the absence of dorsal posterior adductor impressions may be diagnostic. Despite differences, the species are very similar and should provide a firm stratigraphic correlation.

*Sentosia transversa caniensis* subsp. nov.

Pl. 12, figs 8-14

1967 *Sentosia* aff. *praecursor* (Stainbrook); Hill, D., and Woods, J. T., pl. D13, figs 9, 10.

1968 *Sentosia* sp. nov. *b*; Dear, J. F., p. 7, table 1.

**Material:** Holotype, F10509 G.S.Q.; paratypes, F10510, 11454 G.S.Q., F27268-70 U.Q.; figured specimen, F27271 U.Q.; five other registered specimens. All from D151 G.S.Q. = L2252 U.Q., Denny Gully Member, Dawes Range Formation, Cania.

**Description:**

(a) Exterior. The shell is large for the genus. Outline is transversely ovate, with a length, width ratio that decreases from 0.78 in the young to 0.65 at maturity. The body cavity appears to have been relatively deep.

The pedicle valve is strongly convex. In longitudinal profile, curvature normally decreases evenly from the umbo, although it remains strong and constant in the holotype. The transverse profile at the midlength of mature valves is rounded across the venter and gently concave on the spreading flanks. Anteriorly, the venter may be gently convex, flattened, or moderately sulcate. The umbo is prominent and protrudes beyond the hinge margin. Valves are partly flattened along the posterior margin, not auriculate. Cardinal extremities are broadly rounded. There is no interarea. The ornament is not well known. Very fine spines closely cover the body of the valve, and slightly larger spines project posteriorly from the posterior margin in a thick brush.

The brachial valve has very weak even concavity. Some valves have a flattened median sector delimited by obscure angulations of the valve. The postero-lateral regions (auriculations) are large and flat, and curve gently without abrupt change in slope to the visceral region. The ornament is imperfectly preserved; it includes fine prostrate or recumbent spines in a broad peripheral zone, close shallow pits, and growth lines.

(b) Interior. The pedicle valve has a weakly impressed, flabellate, radially striate muscle field. A low myophragm arises 3-4 mm from the umbo and extends at most 10 mm.

The brachial valve has a small bilobate cardinal process whose myophore is directed postero-dorsally or posteriorly. The primary lobes are divergent and each is deeply incised for a diductor base; median muscle boundaries project posteriorly further than the lateral boundaries. Lateral ridges are high and sharp proximally. They extend two thirds to three quarters of the distance to the extremities diverging very little from the hinge margin, except at their extremities where they may be continuous with a variably developed, rounded marginal ridge of thickening. The median septum is very fine, moderately low, and greater than half the length of the valve. Anterior adductor scars are elongate drop-shaped and slightly elevated;

posterior adductor scars are not impressed. Endospines are most prominent in a median sector of 60°-70°. Neither brachial ridges nor homologous grooves are visible.

**Dimensions (mm):**

|                                        | length | width |
|----------------------------------------|--------|-------|
| F10509 G.S.Q., holotype, pedicle valve | 27.8   | 43.0  |
| F27269 G.S.Q., paratype, pedicle valve | 25     | 35.5  |

**Remarks:** *S. transversa caniensis* subsp. nov. typically comes from D151 G.S.Q. (= L2252 U.Q.) in the Denny Gully Member of the Dawes Range Formation at Cania, Yarrol Basin. Dear (1968) listed its occurrence at three other locations in the same member. Of them, the University of Queensland has original collections from two: L2244 U.Q. has only an indeterminate fragment of a *Sentosia*; L2251 U.Q. has a brachial valve which can confidently be assigned to *Sentosia plicata* sp. nov. It was described initially as *Sentosia sinuata* by Dear (1963MS) in an unpublished thesis submitted for the Degree of Doctor of Philosophy at the University of Queensland. Its distinction from *S. transversa transversa* is outlined in the remarks on that species. The subspecies occurs in pebbly, dark greenish-grey, lithic sandstone which is pyritic, zeolitic, and partly calcareous. The clasts include intermediate volcanic rock and dark mudstone fragments. The shells described are all mature and disarticulated; they come from a current-washed shell bed. The inconsistent development of a median flattening or sulcation anteriorly in the pedicle valve suggests that the form is a little more advanced than *S. transversa*, and more nearly approaches the strongly sinuate condition of *Sentosia plicata* sp. nov.

*Sentosia plicata* sp. nov.

Pl. 12, figs 1-7

**Material:** Holotype, F3816 G.S.Q.; paratypes, F3656, 11459 G.S.Q., all from W102 G.S.Q.; F3658, 3728, 11464, 11466 G.S.Q., all from L233 G.S.Q. From the two localities, twelve other specimens. Uppermost strata of Myrtlevale Beds in south-east area of Star Basin. One other figured specimen, F59386 U.Q. from L2251 U.Q., Denny Gully Member, Dawes Range Formation.

**Diagnosis:** Extremely transverse *Sentosia* with length, width ratio 0.56 at maturity; pedicle valve with wide deep sulcus, spreading concave flanks; brachial valve with wide angular fold; cardinal extremities broadly rounded; on pedicle valve, body spines fine, recumbent, arising from elongate spine ridges, no concentric arrangement; equally fine spines in a brush at posterior margin; on brachial valve, pits, and peripherally, fine prostrate spines; cardinal process directed posteriorly, very narrow quadrid myophore; lateral ridges short, high, close to hinge margin; anterior adductors drop-shaped, elevated, the posterior unidentifiable; endospines large, in region of fold only.

**Description:**

(a) Exterior. Shells are of moderate to large size for the genus. They are transversely ovate in outline, and the length, width ratio decreases from 0.73 at a length of 19 mm, to 0.56 at a mature length of 26 mm. The body cavity is fairly shallow. The pedicle valve is moderately convex;



globose in juveniles, later flattened in a median sector, and in mature valves very strongly sulcate medially. The sulcus subtends an angle of  $ca45^\circ$  at the umbo. The flanks are steep initially, later spreading. The umbo is low and broad, and the umbonal slopes sweep in a smooth concave surface to the broad auriculariations. Cardinal extremities are well rounded. There is no interarea.

The valve is ornamented by a dense covering of spines. They are very fine, prostrate or recumbent, and arise from closely spaced, short spine ridges in an en echelon pattern. From the auriculariations, equally fine spines project posteriorly in a sparse brush.

The brachial valve has low to moderate concavity. A prominent, sharply differentiated median flattened or folded sector can be discerned from the umbonal region of all valves. Posteriorly, the visceral region curves gently and evenly into broad auriculariations. The fine detail of ornament is not well preserved as the valves occur in a medium-grained sandstone. Ornament comprises close growth ridges, circular or elongated shallow pits, and peripherally, fine prostrate spines.

(b) Interior. Only a very weak, short myophragm can be distinguished in the pedicle valve.

The brachial valve has a small, particularly narrow bilobate cardinal process directed posteriorly. On the dorsal myophore, the primary lobes are closely parallel and the incisions for insertion of the diductor bases are very shallow and narrow. The lateral ridges are high, short, and closely follow the hinge margin. The median septum is low, very fine, and half the length of the valve. Anterior adductor scars are elongate drop-shaped, slightly elevated, and border the median septum. Posterior adductor elements are obscure. Large, anteriorly directed endospines occur in the median sector that corresponds to the external fold.

Valves have very little secondary thickening.

#### Dimensions (mm):

|                                        | length | width |
|----------------------------------------|--------|-------|
| F3816 G.S.Q., holotype, pedicle valve  | 26     | 46    |
| F3728 G.S.Q., paratype, pedicle valve  | 19     | 26    |
| F3656 G.S.Q., paratype, brachial valve | 19     | 33    |

**Remarks:** The species occurs at L233 and W102 G.S.Q. in the uppermost beds of the Myrtlevale Beds, south-eastern part of the Star Beds. Additionally, it was seen in the same area by the writer, directly to the west of W100 G.S.Q. at the top of the beds. Incompletely preserved *Sentosia* from W78 G.S.Q. in Horse Creek, Star Beds, is probably referable to *S. plicata*. At the localities from which the species is described, the shells occur in a light-brown, flaggy, partly calcareous, feldspathic and micaceous sandstone of medium grain size. Both small and large valves occur side by side, but all are disarticulated.

In the Yarrol Basin, the species occurs in tough dark green medium-grained lithic sandstone at L2251 U.Q., from the uppermost beds of the Denny Gully Member, Dawes Range Formation. It was listed in a table by Dear (1968, table 1) as *Sentosia* sp. nov. b, and assigned to the *Cyrtospirifer sinensis* var. *australis* Fauna. It is a

more advanced species than *S. transversa caniensis* subsp. nov., from L2252 U.Q., Denny Gully Member, which Dear (*op. cit.*) also listed as *Sentosia* sp. nov. b.

Genus LAMINATIA Muir-Wood and Cooper, 1960  
1960 *Laminatia* Muir-Wood and Cooper, p. 189.

**Diagnosis:** See Muir-Wood and Cooper (*loc. cit.*).

**Distribution:** U.S.A., Bradfordian: New Mexico, Percha Formation, Box Member (Famennian, to V - to VI) (Muir-Wood and Cooper, 1960); Colorado, Chaffee Formation (?Famennian, to V) (Kindle, 1909; Muir-Wood and Cooper, 1960; Poole *et al.*, 1967); USSR?, Rudny Altai, Tarkhansk suite, Famennian (to VI) (Grechnishnicova, 1966); Queensland, Star Beds, Famennian (to VI).

*Laminatia jacki* sp. nov.

Pl. 7, figs 1-13

**Material:** Holotype, F11358 G.S.Q.; paratypes, F11351, 11353-7, 11553-4, 11560 G.S.Q.; figured specimens, F11556-9 G.S.Q.; several other registered and unregistered specimens. All come from W77 G.S.Q., Star Beds, Star Basin.

**Diagnosis:** Outline subcircular to transversely quadrate at maturity; ventral umbo large, protuberant; ventral profile strongly and evenly convex; flanks steep to slightly spreading; no trail; cardinal extremities right-angled or acute; greatest width at the hinge; no interarea; dorsal profile moderately concave; no geniculation or trail; both valves with strongly laminose surface, and spines of one order of size; spines fine, in single row close to the hinge, and from short spine ridges on the laminae; cardinal process sessile, bilobate, myophore, quadrifid; lateral ridges short, divergent from the hinge margin; median very low between adductors, septum anteriorly elevated; adductor scars broadly triangular, undifferentiated, elevated, smooth.

#### Description:

(a) Exterior. These are very small, strongly concavo-convex shells with subcircular to semicircular outline, and narrow body cavity.

The pedicle valve is subcircular, slightly wider than long in juveniles, more transverse toward maturity when the length is 65-70 per cent of the width. The umbo is broad and projects beyond the hinge line. In longitudinal profile, the valve is quite strongly convex, with the curvature decreasing evenly toward the front. In transverse profile, curvature is considerable across the venter, and while the flanks are steep in juveniles, they spread toward maturity. Auriculariations are usually well developed in adult valves. Cardinal extremities are right-angled early in ontogeny, later acute. Greatest width is at the cardinal margin. There is no interarea. The valve is ornamented by prominent concentric laminae and spines. The laminae cover the entire shell. They are slightly overlapping, quite regular, and relatively wide (three occur in 1 mm medially on the venter of a mature specimen). Spines are very fine and there is no size differentiation at a given growth stage. A single row of laterally



directed spines occurs close to the cardinal margin, usually approximately six on each side of the umbo. Each lamina is crossed by numerous short spine ridges which terminate in fine, almost prostrate spines. The spine ridges are neither radially aligned with respect to the umbo, nor do they cross more than one lamina.

The brachial valve is most deeply concave in the umbonal area (juvenile growth stages). The umbo, or protogular node, is small and convex. The auriculations are large and flattened. The valve is evenly curved, and neither geniculation nor trail occurs. Like the pedicle valve, the brachial is laminose and quite closely spinose. A single spine row near the cardinal margin on each side of the umbo is characteristic.

(b) Interior. Teeth are not developed in the pedicle valve. The obscure muscle areas are separated medially by a very short groove. Extremely fine endospines cover the surface. The shell substance is believed to have been very thin, as the external laminae and spine ridges are clearly reflected on the inner surface.

The brachial valve has a small posteriorly directed, bilobate cardinal process. The lobes are not widely divergent, but are separated nearly to the base of the structure. Primary lobes are incised along their dorsal surface for reception of diductor muscle bases. Lateral ridges are short, fairly obscure, and diverge from the base of the cardinal process at an angle of *ca* 30° to the hinge margin. A fine median ridge or septum extends from the cardinal process to the midlength. It is very low posteriorly, between the adductor scars and is highest anteriorly. Adductor muscle scars are triangular in outline, slightly elevated, and smooth; there is no differentiation of anterior and posterior elements. The interior surface is covered by fine endospines which are largest in the anterior median portion of the valve.

*Dimensions (mm):*

|                                         | length | width |
|-----------------------------------------|--------|-------|
| F11358 G.S.Q., holotype, brachial valve | 4.0    | 5.4   |
| F11356 G.S.Q., paratype, pedicle valve  | 6.3    | 8.6   |
| F11353 G.S.Q., paratype, brachial valve | 5.2    | 9.0   |

*Remarks:* *Laminatia jacki* sp. nov. is known from two localities in the Star Beds, Star Basin: W77 G.S.Q. in a tributary gully of Horse Creek on its north side, and L1058 G.S.Q. in a tributary gully of the same creek, along strike to the south. At each locality it is associated with *Australosia* gen. nov., *Rhytiophora*, and ?*Sentosia* in green-brown fractured mudstone. It is thought that the disarticulation of valves at both localities is due to organic activity or extremely mild currents, as there is no evidence of either current sorting or dispersal of associated brachiopod (*Emanuella*?) groups or "nests".

The species appears to be closely related to the type of *Laminatia*, *Productella laminata* Kindle, 1909 from the Chaffee Formation of Colorado, and Percha Formation of New Mexico. Muir-Wood and Cooper (1960, p. 189) described it as having two series of spine ridges, the larger extending across the laminae, the smaller sited anteriorly; in this respect, and in its larger size, it differs from *L. jacki*. There is some doubt whether presence of spine ridges in two series is constant, even in the type species, as the type specimen figured by Kindle (1909, pl. 4, fig. 13) from Shoshone, Colorado appears to have undifferentiated spine ridges. Grechnishnicova (1966, pl. 8, figs. 4, 5) figured generally similar shells as *Echinoconchus biseriatus* (Hall) from the brachiopod beds of the Tarkansk suite (Famennian, to VI), Rudny Altai, USSR. The internal structure of the brachial valve, especially the cardinal process, was not indicated, so that its precise generic affinities remain uncertain.

The name of the species commemorates Mr. R. L. Jack, one of Queensland's foremost pioneer geologists, and the first man to describe and map the strata of the Star Basin.



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## APPENDIX

## UPPER DEVONIAN FOSSIL LOCALITIES IN THE STAR AND YARROL BASINS

## Geological Survey of Queensland Collections

- W77 10 chains N.E. of the crossing of the southern branch of Horse Ck. by the Dotswood-Star road.  
Collection: J. T. Woods and D. H. Wyatt, 13/10/1960.
- W78 On the south bank of the southern branch of Horse Ck., 41 chains S.E. of the Dotswood-Star road crossing.  
Collection: J. T. Woods and D. H. Wyatt, 14/10/1960.
- W81 On the southern branch of Horse Ck., 41 chains S.E. of the Dotswood-Star road crossing.  
Collection: J. T. Woods and D. H. Wyatt, 14/10/1960.
- W83 9 chains E. of the Dotswood-Star road, 2½ miles S. of Star Homestead.  
Collection: J. T. Woods and D. H. Wyatt, 14/10/1960.
- W87 In Horse Ck., 50 chains E. of the Dotswood-Star road crossing.  
Collection: J. T. Woods and D. H. Wyatt, 14/10/1960.
- W93 Map reference 472395 Dotswood 1-mile military Sheet.  
Collection: J. T. Woods and D. H. Wyatt, 18/10/1960.
- W94 Map reference 47433935 Dotswood 1-mile military Sheet.  
Collection: J. T. Woods and D. H. Wyatt, 18/10/1960.
- W98 Map reference 38003157 Dotswood 1-mile military Sheet.  
Collection: J. T. Woods and D. H. Wyatt, 19/10/1960.
- W100 Map reference 38053250 Dotswood 1-mile military Sheet.  
Collection: J. T. Woods, and D. H. Wyatt, 19/10/1960.
- W101 Map reference 36863360 Dotswood 1-mile military Sheet.  
Collection: J. T. Woods and D. H. Wyatt, 19/10/1960.
- W102 Map reference 36003535 Dotswood 1-mile military Sheet.  
Collection: J. T. Woods and D. H. Wyatt, 19/10/1960.
- D144 E. of basalt-capped peak, 1 mile W. of junction of Kroombit Oaky Ck. and Three Moon Ck., Cania.  
Collection: J. F. Dear, 1964.
- D145 In 3rd gully running into Kroombit Oaky Ck. from S.W., 5,600 feet W.S.W. of junction with Kroombit Oaky Ck.  
Collection: J. F. Dear, 1964.
- D146 In 3rd gully running into Kroombit Oaky Ck. from S.W., 100 yards W. of locality D145.  
Collection: J. F. Dear, 1964.
- D151 German Gully, 100 yards up from junction with South Kariboe Ck., N.W. of Cania.  
Collection: J. F. Dear, 1964.
- L233 Map reference 36033480 Dotswood 1-mile military Sheet.  
Collection: D. H. Wyatt, 5/1/1962.
- L343 In a branch of Pintpot Ck. approx. 82 chains N.N.W. of Lollypop Dam; map reference 00705550 Dotswood 1-mile military Sheet.  
Collection: D. H. Wyatt and D. W. Dearne, 8/1962.
- L345 Map reference 039487 Dotswood 1-mile military Sheet.  
Collection: D. H. Wyatt and D. W. Dearne, 9/1962.
- L357 Map reference 088464 Dotswood 1-mile military Sheet.  
Collection: D. H. Wyatt and D. W. Dearne, 8/1962.
- L358 Map reference 076461 Dotswood 1-mile military Sheet.  
Collection: D. H. Wyatt and D. W. Dearne, 8/1962.
- L367 Por. 2; Parish Somer, County Burdekin. 0.4 mile S. of N.E. corner. (Strata dragged up by dacite plug.)  
Collection: N. McTaggart (W. D. Mott & Associates) 3/1/1963.
- L539 Map reference 32756800 Thornton Gap special 1-mile military Sheet.  
Collection: D. H. Wyatt and D. Clarke, 1964.
- L818 ½ mile N.N.W. of Myrtlevalle Hut in Myrtlevalle Beds on Mt. St. Michael holding, S. of "Dotswood"- "Fanning" track. Map reference 384293 Dotswood 1-mile military Sheet.  
Collection: R. G. McKellar, P. J. G. Fleming, and D. H. Wyatt, 6/1965.
- L949 Small tributary of McBride Ck. Map reference 33420355 Rockhampton 1:250,000 Sheet area.  
Collection: A. G. Kirkegaard, 1965.
- L951 W. of McBride Ck., Gelobera Range. Map reference 34050322 Rockhampton 1:250,000 Sheet area.  
Collection: A. G. Kirkegaard, 1965.
- L995 Railway line E. of Muranu. Map reference 32750482 Rockhampton 1:250,000 Sheet area.  
Collection: J. F. Dear and A. G. Kirkegaard, 8/1965.
- L1036 On N. side of small gully entering the Dee River from the W., ¾ mile upstream from the confluence with Boulder Ck. Map reference 327049 Rockhampton 1:250,000 Sheet area.  
Collection: R. G. McKellar, 30/7/1968.
- L1038 Map reference 40365633 Townsville 1:250,000 Sheet area.  
Collection: D. H. Wyatt, 1966.
- L1043 Map reference 40875695 Townsville 1:250,000 Sheet area.  
Collection: D. H. Wyatt, 1967.
- L1051 In tributary of Percy Ck. Map reference 469399 Dotswood 1:100,000 Sheet area.  
Collection: R. G. McKellar, 9/1968.
- L1052 40 chains slightly E. of S. of dam on S. tributary of Ten Mile Ck., Marlow Station. Map reference 216282 Dotswood 1:100,000 Sheet area.  
Collection: R. G. McKellar, 9/1968.
- L1056 Immediately N. of the road, 2¼ miles N.E. of Star Homestead. Map reference 42255800 Townsville 1:250,000 Sheet area.  
Collection: R. G. McKellar, 9/1968.
- L1057 6.6 chains S.E. of the road crossing on Horse Ck. near Star Homestead. Map reference 422575 Townsville 1:250,000 Sheet area.  
Collection: R. G. McKellar and D. H. Wyatt, 9/1968.
- L1058 3.6 chains S.S.E. of the road crossing on Horse Ck. near Star Homestead. Map reference 421575 Townsville 1:250,000 Sheet area.  
Collection: R. G. McKellar and D. H. Wyatt, 9/1968.
- L1059 S. of Paynes Lagoon Homestead in S. tributary of Boundary Ck., 7 chains S. of confluence of tributary and main creek.  
Collection: R. G. McKellar and D. H. Wyatt, 9/1968.
- L1060 90 feet S. of locality L1059 in small gully off main tributary.  
Collection: R. G. McKellar and D. H. Wyatt, 9/1968.
- L1061 10 chains S. of locality L1059 in main tributary.  
Collection: R. G. McKellar and D. H. Wyatt, 9/1968.
- University of Queensland Collections
- L1192 Golden Gully. Map reference 26.3E, 23.2N. Westwood 1-mile military Sheet.  
Collection: W. G. H. Maxwell.
- L1194 Second crossing of Dee River. Map reference 27.3E., 49.3N. Westwood 1-mile military Sheet.  
Collection: W. G. H. Maxwell.
- L1195 Golden Gully. Map reference 26.3E., 53.2N. Westwood 1-mile military Sheet.  
Collection: W. G. H. Maxwell.
- L1197 South of Boulder Ck. Map reference 25.3E., 47.8N. Westwood 1-mile military Sheet.  
Collection: W. G. H. Maxwell.
- L1984 In 3rd gully running into Kroombit Oaky Ck. from S.W., 2¼ miles N. of Cania.  
Collection: J. F. Dear, 1960.
- L1991 Racecourse Gully, 1 mile N.E. of Cania.  
Collection: J. F. Dear, 1960.
- L1994 In 3rd gully running into Kroombit Oaky Ck. from S.W., 2¼ miles N. of Cania, and approximately 100 yards E. of locality L1984.  
Collection: J. F. Dear, 1960.
- L2229 Tributary of Grove Gully, ¾ mile S.E. of junction with South Kariboe Ck.  
Collection: J. F. Dear, 1960.



- L2232 On ridge separating Kroombit Oaky Ck. and Milkman Ck.,  
Cania.  
Collection: J. F. Dear, 1960.
- L2235 E. of basalt—capped peak 1 mile W. of junction of Kroom-  
bit Oaky Ck. and Three Moon Ck., Cania.  
Collection: J. F. Dear, 1960.
- L2237 Low ridge W. of Racecourse Gully, 1 mile N.E. of Cania.  
Collection: J. F. Dear, 1960.
- L2239 Ridge crest on Dawes Range,  $2\frac{1}{2}$  miles N.W. of Cania.  
Collection: J. F. Dear, 1960.
- L2247 Ridge crest on Dawes Range,  $2\frac{1}{2}$  miles N.W. of Cania and  
100 yards N.E. of locality L2239.  
Collection: J. F. Dear, 1960.
- L2251 On ridge N. of Fig Tree Gully, 2 miles N.W. of Cania.  
Collection: J. F. Dear, 1960.
- L2252 In German Gully, 100 yards up from the junction with  
South Kariboe Ck., 4 miles N.W. of Cania.  
Collection: J. F. Dear, 1960.
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# EXPLANATION OF PLATE 1

FIGS 1-19. *Australosia starensis* gen. et sp. nov. All specimens from W77 G.S.Q.

1. F4106 G.S.Q., paratype, pedicle valve; (a) rubber cast of exterior,  $\times 1$ ; (b) the same,  $\times 4$ .
2. F4101 G.S.Q., paratype, rubber cast of pedicle valve exterior,  $\times 4$ .
3. F11337 G.S.Q., paratype, rubber cast of pedicle valve exterior, small cicatrix,  $\times 4$ .
4. F4107 G.S.Q., rubber cast of pedicle valve exterior, very large cicatrix,  $\times 4$ .
5. F11324 G.S.Q., holotype; (a) rubber cast of exterior, incomplete pedicle valve,  $\times 1$ ; (b) the same,  $\times 4$ ; (c) natural mould, brachial valve exterior,  $\times 4$ ; (d) rubber cast of interarea of pedicle valve, and brachial valve exterior,  $\times 4$ .
6. F11335 G.S.Q., natural mould pedicle valve interior,  $\times 4$ .
7. F11323 G.S.Q., rubber cast deformed brachial valve, to show posterior surface of cardinal process,  $\times 6$ .
8. F4105 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 4$ .
9. F11359 G.S.Q., rubber cast, pedicle valve exterior,  $\times 4$ .
10. F11333 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 4$ .
11. F11336 G.S.Q., natural mould of pedicle valve interior,  $\times 4$ .
12. F11322 G.S.Q., rubber cast of brachial valve exterior, and interarea of pedicle valve,  $\times 4$ .
13. F11561 G.S.Q., rubber cast of pedicle valve exterior showing hinge spines, elongate cicatrix,  $\times 4$ .
14. F11331 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 4$ .
15. F11325 G.S.Q., rubber cast of brachial valve exterior, and interarea of pedicle valve,  $\times 4$ .
16. F11320 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 6$ .
17. F11328 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 6$ .
18. F11326 G.S.Q., natural mould of brachial valve exterior,  $\times 4$ .
19. F11330 G.S.Q., paratype; (a) natural mould of brachial valve exterior and interarea of pedicle valve,  $\times 6$ ; (b) rubber cast of the same, showing pseudodeltidium,  $\times 6$ .

FIG. 20. *Spinulicosta dotswoodae* sp. nov.

20. F11292 G.S.Q., holotype, pedicle valve; (a) rubber cast of exterior,  $\times 1$ ; (b) the same,  $\times 2$ ; (c) the same, lateral view,  $\times 2$ ; (d) natural mould of interior,  $\times 2$ ; (e) the same, posterior view,  $\times 4$ ; (f) rubber cast of interior, anterodorsal view,  $\times 4$ ; (g) rubber cast of exterior,  $\times 4$ . L367 G.S.Q.



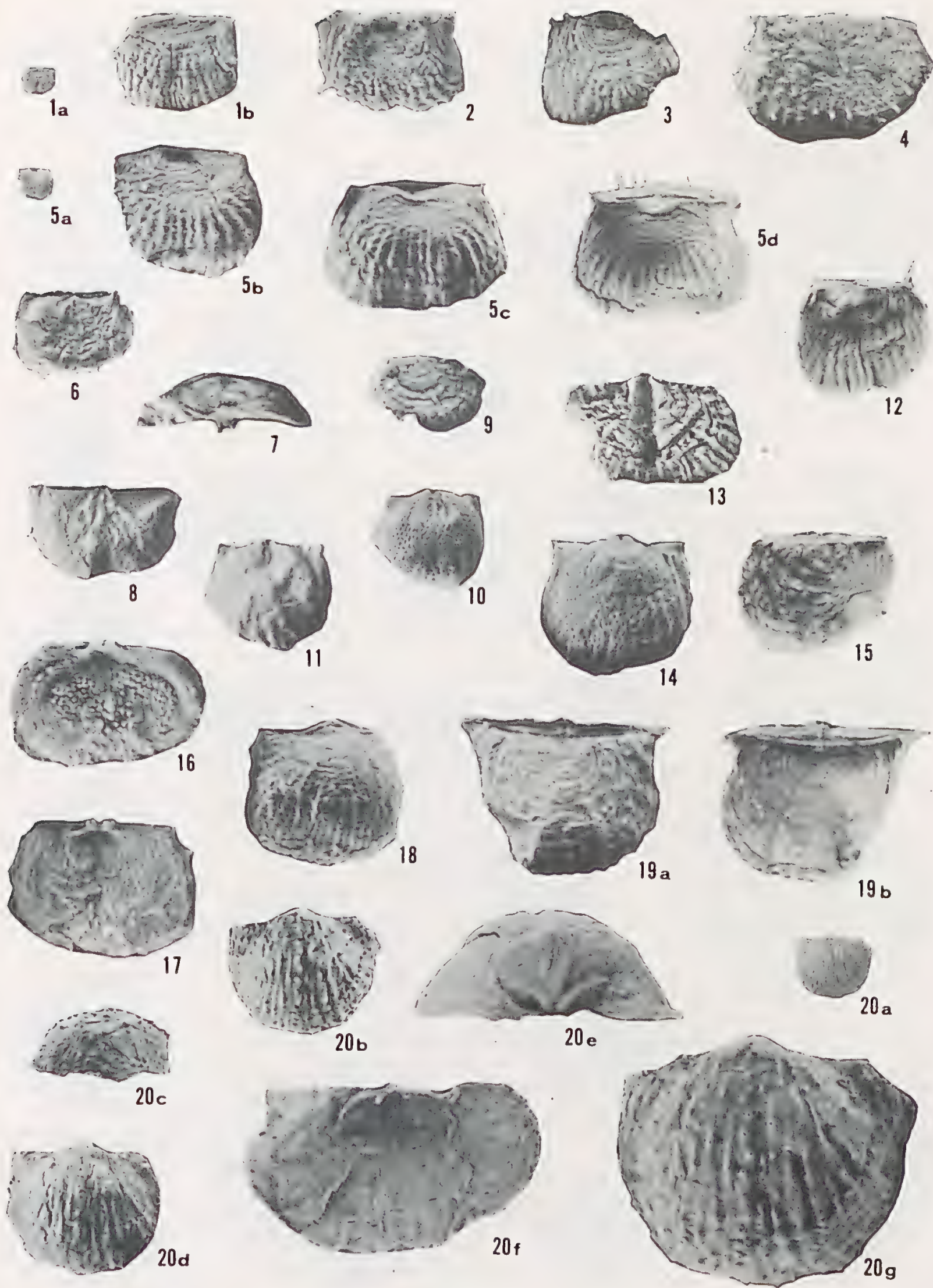


PLATE 1



## EXPLANATION OF PLATE 2

FIGS 1-24. *Spinulicosta dotswoodae* sp. nov.

1. F11304 G.S.Q., paratype, pedicle valve; (a) rubber cast of exterior,  $\times 2$ ; (b) the same, right lateral view,  $\times 4$ . W100 G.S.Q.
2. F11303 G.S.Q., paratype, rubber cast of juvenile pedicle valve exterior,  $\times 4$ . W100 G.S.Q.
3. F11312 G.S.Q., rubber cast of pedicle valve exterior,  $\times 2$ . L367 G.S.Q.
4. F11311 G.S.Q., rubber cast of pedicle valve exterior, ventrolateral view,  $\times 2$ . L367 G.S.Q.
5. F11296 G.S.Q., rubber cast of pedicle valve exterior,  $\times 2$ . L367 G.S.Q.
6. F10504 G.S.Q., rubber cast of pedicle valve exterior,  $\times 2$ . L367 G.S.Q.
7. F11572 G.S.Q., paratype, rubber cast of pedicle valve exterior,  $\times 2$ . L367 G.S.Q.
8. F11298 G.S.Q., rubber cast of incomplete pedicle valve exterior,  $\times 2$ . L367 G.S.Q.
9. F11302 G.S.Q., paratype, rubber cast of pedicle valve exterior,  $\times 2$ . W100 G.S.Q.
10. F11293 G.S.Q., rubber cast of pedicle valve exterior,  $\times 2$ . L367 G.S.Q.
11. F11310 G.S.Q., paratype, pedicle valve; (a) rubber cast of exterior,  $\times 2$ ; (b) natural mould of interior,  $\times 2$ . L367 G.S.Q.
12. F11295 G.S.Q., rubber cast of incomplete pedicle valve exterior,  $\times 2$ . L367 G.S.Q.
13. F11294 G.S.Q., deformed pedicle valve; (a) rubber cast of exterior,  $\times 2$ ; (b) natural mould of interior,  $\times 2$ . L367 G.S.Q.
14. F11297 G.S.Q., rubber cast of pedicle valve exterior,  $\times 2$ . L367 G.S.Q.
15. F10506 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 2$ . L367 G.S.Q.
16. F10504 G.S.Q., natural mould of pedicle valve interior,  $\times 2$ . L367 G.S.Q.
17. F10505 G.S.Q., paratype, pedicle valve; (a) natural mould of interior,  $\times 2$ ; (b) rubber cast of interior; note tubular continuations of external spines,  $\times 4$ . L367 G.S.Q.
18. F11308 G.S.Q., paratype, natural mould of brachial valve exterior,  $\times 2$ . W100 G.S.Q.
19. F11306 G.S.Q., rubber cast of brachial valve exterior,  $\times 2$ . W100 G.S.Q.
20. F3710 G.S.Q., paratype, brachial valve; (a) rubber cast of interior,  $\times 2$ ; (b) the same,  $\times 4$ . W100 G.S.Q.
21. F11307 G.S.Q., paratype, brachial valve; (a) natural mould of exterior,  $\times 2$ ; (b) rubber cast of exterior,  $\times 2$ ; (c) the same,  $\times 4$ . W100 G.S.Q.
22. F11309 G.S.Q., rubber cast of brachial valve interior,  $\times 4$ . W100 G.S.Q.
23. F11291 G.S.Q., pedicle valve; (a) rubber cast of exterior,  $\times 2$ ; (b) the same,  $\times 4$ . L367 G.S.Q.
24. F10505, 10506, 11572 G.S.Q., paratypes, natural moulds,  $\times 1$ . L367 G.S.Q.





PLATE 2

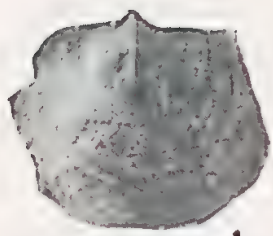


### EXPLANATION OF PLATE 3

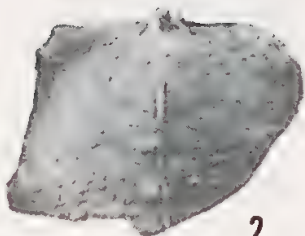
Figs 1-15. *Morganella maxwelli* gen. et sp. nov.

1. F11396 G.S.Q., rubber cast of brachial valve interior,  $\times 1$ . L1036 G.S.Q.
2. F11395 G.S.Q., rubber cast of incomplete brachial valve interior,  $\times 1.5$ . L1036 G.S.Q.
3. F15107 U.Q., natural mould of pedicle valve interior,  $\times 1$ ; figured Maxwell, 1954, pl. 1, fig. 4. L1194 U.Q.
4. F15108 U.Q., natural mould of pedicle valve interior,  $\times 1$ ; figured Maxwell, 1954, pl. 1, fig. 2. L1194 U.Q.
5. F11399 G.S.Q., paratype, pedicle valve; (a) natural mould interior, posterior view,  $\times 1$ ; (b) the same, ventral view,  $\times 1$ . L1036 G.S.Q.
6. F11409 G.S.Q., natural mould of pedicle valve interior,  $\times 1$ . L949 G.S.Q.
7. F11402 G.S.Q., paratype, rubber cast of incomplete pedicle valve exterior,  $\times 1.5$  L1036 G.S.Q.
8. F11400 G.S.Q., natural mould of pedicle valve interior,  $\times 1$ . L1036 G.S.Q.
9. F11391 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 1.5$ . L1036 G.S.Q.
10. F11398 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 1.5$ . L1036 G.S.Q.
11. F11392 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 1.5$ . L1036 G.S.Q.
12. F15104 U.Q., rubber cast of brachial valve interior,  $\times 1.5$ ; figured Maxwell, 1954, pl. 1, fig. 1. L1194 U.Q.
13. F15106 U.Q., paratype, rubber cast of incomplete pedicle valve interior,  $\times 1.5$ ; figured obliquely Maxwell, 1954, pl. 1, fig. 3. L1194 U.Q.
14. F11393 G.S.Q., paratype, natural mould of brachial valve exterior,  $\times 1.5$ . L1036 G.S.Q.
15. F11397 G.S.Q., holotype, pedicle valve; (a) natural mould of interior,  $\times 1$ ; (b) the same, right lateral view,  $\times 1.5$ ; (c) the same, ventral view,  $\times 1.5$ . L1036 G.S.Q.

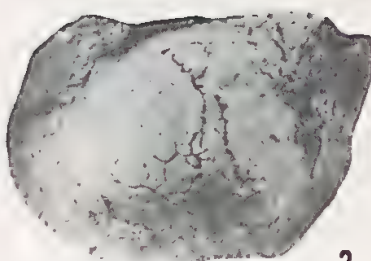




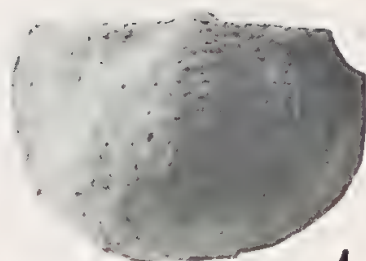
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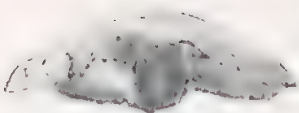
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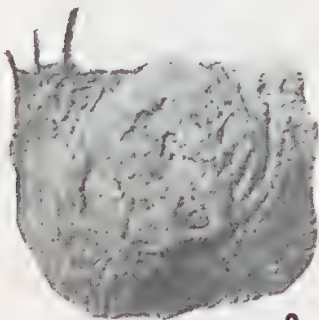
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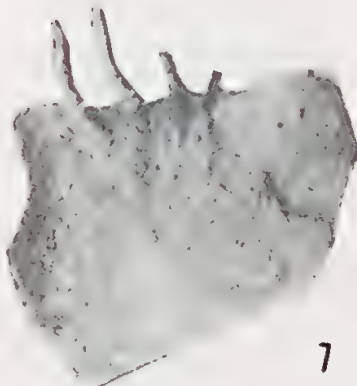
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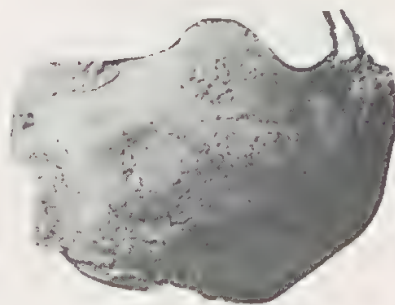
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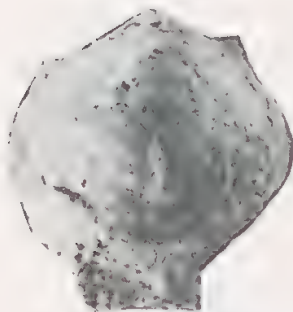
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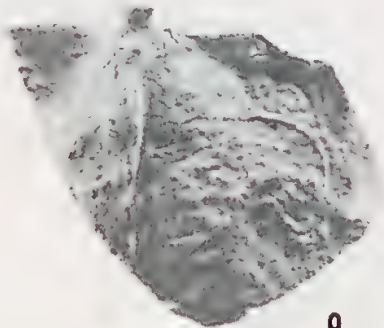
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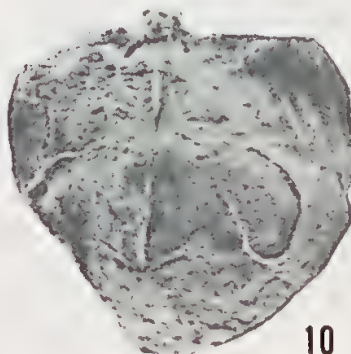
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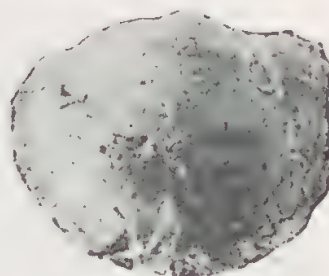
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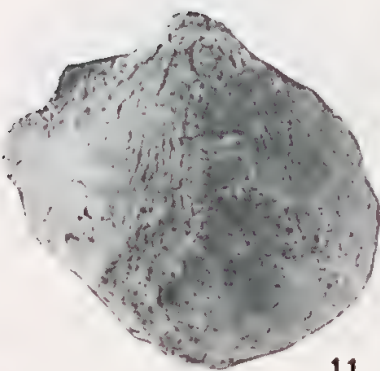
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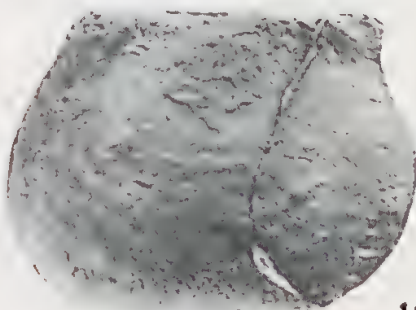
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15a



11



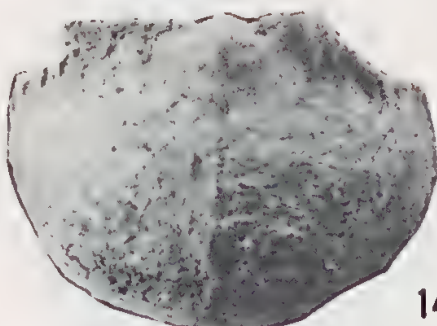
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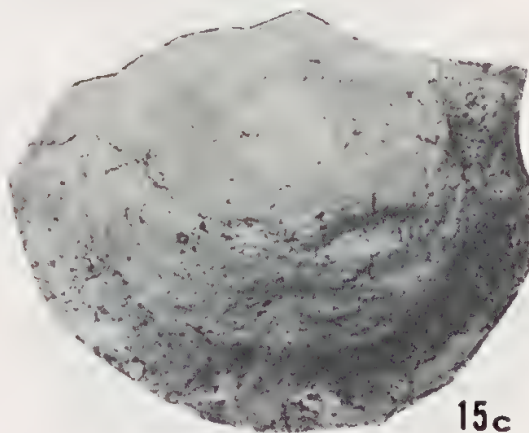
15b



13



14



15c

PLATE 3



#### EXPLANATION OF PLATE 4

FIGS 1-15. *Strophopductus rugosus* sp. nov.

1. F11280 G.S.Q., natural mould, pedicle valve interior,  $\times 2$ . W81 G.S.Q.
2. F11282 G.S.Q., rubber cast of brachial valve exterior,  $\times 4$ . W81 G.S.Q.
3. F3959 G.S.Q., natural mould, pedicle valve interior,  $\times 2$ . W81 G.S.Q.
4. F11278 G.S.Q., rubber cast of pedicle valve exterior,  $\times 4$ . W81 G.S.Q.
5. F11283 G.S.Q., rubber cast of brachial valve exterior,  $\times 4$ . W81 G.S.Q.
6. F11489 G.S.Q., paratype; (a) rubber cast of brachial valve, and interarea of pedicle valve,  $\times 2$ ; (b) rubber cast of pedicle valve exterior,  $\times 2$ ; (c) the same as (a),  $\times 4$ . L1059 G.S.Q.
7. F3644 G.S.Q., rubber cast of pedicle valve exterior,  $\times 4$ . W94 G.S.Q.
8. F11488 G.S.Q., paratype, rubber cast of immature pedicle valve exterior,  $\times 4$ . L1059 G.S.Q.
9. F11487 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 4$ . L1059 G.S.Q.
10. F11490 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 4$ . L1059 G.S.Q.
11. F11281 G.S.Q., holotype; (a) rubber cast of brachial valve exterior,  $\times 4$ ; (b) rubber cast of pedicle valve exterior,  $\times 4$ . W81 G.S.Q.
12. F11491 G.S.Q., paratype, rubber cast of incomplete pedicle valve exterior,  $\times 4$ . L1059 G.S.Q.
13. F11279 G.S.Q., natural mould of pedicle valve interior,  $\times 4$ . W81 G.S.Q.
14. F11493 G.S.Q., paratype, rubber cast of pedicle valve exterior,  $\times 4$ . L1059 G.S.Q.
15. F3958 G.S.Q., brachial valve; (a) rubber cast of exterior,  $\times 1$ ; (b) the same,  $\times 6$ . W81 G.S.Q.

FIG. 16. *Bispinopductus?* sp.

16. F11403 G.S.Q., brachial valve; (a) rubber cast of exterior,  $\times 1$ ; (b) natural mould of exterior,  $\times 1.5$ . L1036 G.S.Q.





PLATE 4



#### EXPLANATION OF PLATE 5

FIGS 1-19. *Whidbornella* (*Dotswoodia*) *wyatti* subgen. et sp. nov.

1. F11419 G.S.Q., rubber cast of brachial valve exterior,  $\times 1.5$ . L1038 G.S.Q.
2. F11422 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 1.5$ . L1038 G.S.Q.
3. F11417 G.S.Q., umbonal region of pedicle valve exterior,  $\times 2$ . L1038 G.S.Q.
4. F11428 G.S.Q., paratype, pedicle valve; (a) rubber cast of interior,  $\times 2$ ; (b) natural mould of interior,  $\times 2$ . L1038 G.S.Q.
5. F11418 G.S.Q., paratype, rubber cast of incomplete pedicle valve,  $\times 1.5$ . L1038 G.S.Q.
6. F11426 G.S.Q., natural mould of brachial valve exterior,  $\times 1$ . L1038 G.S.Q.
7. F11421 G.S.Q., natural mould of juvenile pedicle valve interior,  $\times 1.5$ . L1038 G.S.Q.
8. F11412 G.S.Q., paratype, pedicle valve exterior,  $\times 1$ . L1038 G.S.Q.
9. F11486 G.S.Q., rubber cast of brachial valve exterior,  $\times 2$ . L1060 G.S.Q.
10. F11482 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 1.5$ . L1060 G.S.Q.
11. F11413 G.S.Q., paratype, brachial valve interior,  $\times 1.5$ . L1060 G.S.Q.
12. F11477 G.S.Q., holotype, pedicle valve; (a) rubber cast of exterior,  $\times 1$ ; (b) the same,  $\times 1.5$ . L1060 G.S.Q.
13. F11416 G.S.Q., paratype, rubber cast of pedicle valve exterior,  $\times 1.5$ . L1038 G.S.Q.
14. F11479 G.S.Q., paratype, rubber cast of pedicle valve exterior,  $\times 1.5$ . L1060 G.S.Q.
15. F11478 G.S.Q., paratype, brachial valve; (a) natural mould of interior,  $\times 1.5$ ; (b) natural mould of exterior,  $\times 1.5$ . L1060 G.S.Q.
16. F11476 G.S.Q., paratype, rubber cast of incomplete pedicle valve exterior,  $\times 1.5$ . L1060 G.S.Q.
17. F11484 G.S.Q., paratype, natural mould of brachial valve exterior, incomplete posteriorly,  $\times 1.5$ . L1060 G.S.Q.
18. F11474 G.S.Q., paratype, rubber cast of pedicle valve exterior,  $\times 1.5$ . L1060 G.S.Q.
19. F11468 G.S.Q., paratype, pedicle valve; (a) natural mould of interior,  $\times 1$ ; (b) the same,  $\times 1.5$ . L1060 G.S.Q.





PLATE 5



#### EXPLANATION OF PLATE 6

FIGS 1-4. *Mesoplica?* sp.

1. F11404 G.S.Q., pedicle valve; (a) natural mould of interior,  $\times 1$ ; (b) the same,  $\times 1.5$ . D146 G.S.Q.
2. F27299 U.Q., rubber cast of pedicle valve exterior, umbonal region,  $\times 2$ . L2232 U.Q.
3. F27296 U.Q., rubber cast of pedicle valve exterior,  $\times 1.5$ . L2232 U.Q.
4. F27298 U.Q., rubber cast of brachial valve interior,  $\times 2$ . L2232 U.Q.

FIG. 5. *Strophopproductus rugosus* sp. nov.

5. F11490 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 4$ . Counterpart figured pl. 4, fig. 10. L1059 G.S.Q.

FIGS 6-15. *Acanthatia fragilis* sp. nov.

6. F11317 G.S.Q. paratype, rubber cast of pedicle valve exterior,  $\times 2$ . L345 G.S.Q.
7. F11501 G.S.Q., paratype, rubber cast of brachial valve exterior, and interarea of pedicle valve,  $\times 3$ . L1059 G.S.Q.
8. F11316 G.S.Q., holotype; (a) rubber cast of pedicle valve exterior,  $\times 1$ ; (b) the same,  $\times 3$ ; (c) rubber cast of brachial valve exterior, and interarea of pedicle valve,  $\times 3$ . L345 G.S.Q.
9. F11492 G.S.Q., rubber cast of brachial valve exterior,  $\times 4$ . L1059 G.S.Q.
10. F11499 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 3$ . L1059 G.S.Q.
11. F11318 G.S.Q., paratype, pedicle valve exterior,  $\times 2$ . L345 G.S.Q.
12. F11495 G.S.Q., paratype, rubber cast of pedicle valve exterior,  $\times 3$ . L1059 G.S.Q.
13. F5164 G.S.Q., paratype, brachial valve; (a) rubber cast of interior,  $\times 4$ ; (b) rubber cast of exterior,  $\times 4$ . L345 G.S.Q.
14. F11502 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 3$ . L1059 G.S.Q.
15. F11500 G.S.Q., paratype, pedicle valve; (a) rubber cast of exterior,  $\times 3$ ; (b) rubber cast of interior,  $\times 3$ . L1059 G.S.Q.



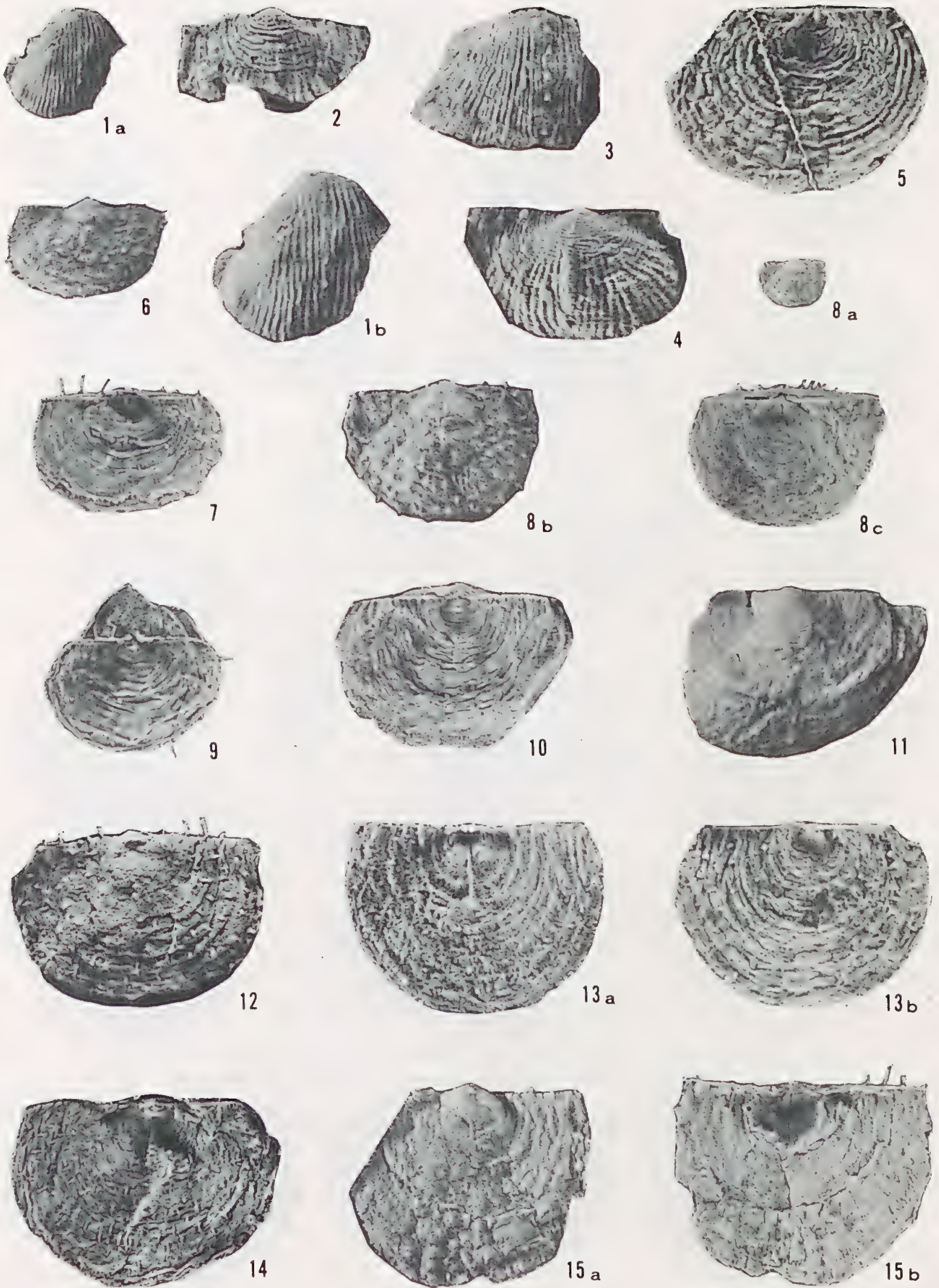


PLATE 6



#### EXPLANATION OF PLATE 7

Figs 1-13. *Laminatia jacki* sp. nov.

All specimens from W77 G.S.Q.

1. F11354 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 4$ .
2. F11358 G.S.Q., holotype, brachial valve; (a) rubber cast of interior,  $\times 4$ ; (b) rubber cast of exterior,  $\times 4$ .
3. F11355 G.S.Q., paratype, rubber cast of incomplete pedicle valve exterior,  $\times 4$ .
4. F11559 G.S.Q., rubber cast of pedicle valve interior,  $\times 4$ .
5. F11554 G.S.Q., paratype, rubber cast of pedicle valve interior,  $\times 4$ .
6. F11558 G.S.Q., rubber cast of brachial valve exterior,  $\times 4$ .
7. F11556 G.S.Q., natural mould of pedicle valve interior,  $\times 6$ .
8. F11560 G.S.Q., paratype, rubber cast of incomplete brachial valve interior,  $\times 6$ .
9. F11357 G.S.Q., paratype, rubber cast of pedicle valve exterior,  $\times 4$ .
10. F11553 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 4$ .
11. F11557 G.S.Q., natural mould of brachial valve exterior,  $\times 4$ .
12. F11353 G.S.Q., paratype, brachial valve; (a) rubber cast of exterior,  $\times 1$ ; (b) the same,  $\times 4$ .
13. F11356 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 4$ .

Figs 14-26. *Mesoplica? hillae* sp. nov.

14. F11517 G.S.Q., paratype, rubber cast of immature pedicle valve exterior,  $\times 3$ . L358 G.S.Q.
15. F11367 G.S.Q., natural mould of pedicle valve interior,  $\times 1.5$ . L343 G.S.Q.
16. F11363 G.S.Q., rubber cast of pedicle valve exterior,  $\times 2$ . L343 G.S.Q.
17. F11360 G.S.Q., pedicle valve; (a) natural mould of interior,  $\times 2$ ; (b) the same, lateral view,  $\times 2$ . L1043 G.S.Q.
18. F11370 G.S.Q., natural mould of pedicle valve interior,  $\times 2$ . L1043 G.S.Q.
19. F11507 G.S.Q., paratype, pedicle valve; (a) natural mould of interior,  $\times 2$ ; (b) rubber cast of exterior,  $\times 2$ . L358 G.S.Q.
20. F11515 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 2$ . L358 G.S.Q.
21. F11516 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 3$ . L358 G.S.Q.
22. F11511 G.S.Q., holotype, rubber cast of brachial valve interior,  $\times 2$ . L358 G.S.Q.
23. F11508 G.S.Q., paratype, natural mould of brachial valve exterior, and hinge spines of pedicle valve,  $\times 2$ . L358 G.S.Q.
24. F11514 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 3$ . L358 G.S.Q.
25. F11509 G.S.Q., paratype, rubber cast of brachial valve interior, note ?dental sockets  $\times 3$ . L358 G.S.Q.
26. F11513 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 3$ . L358 G.S.Q.



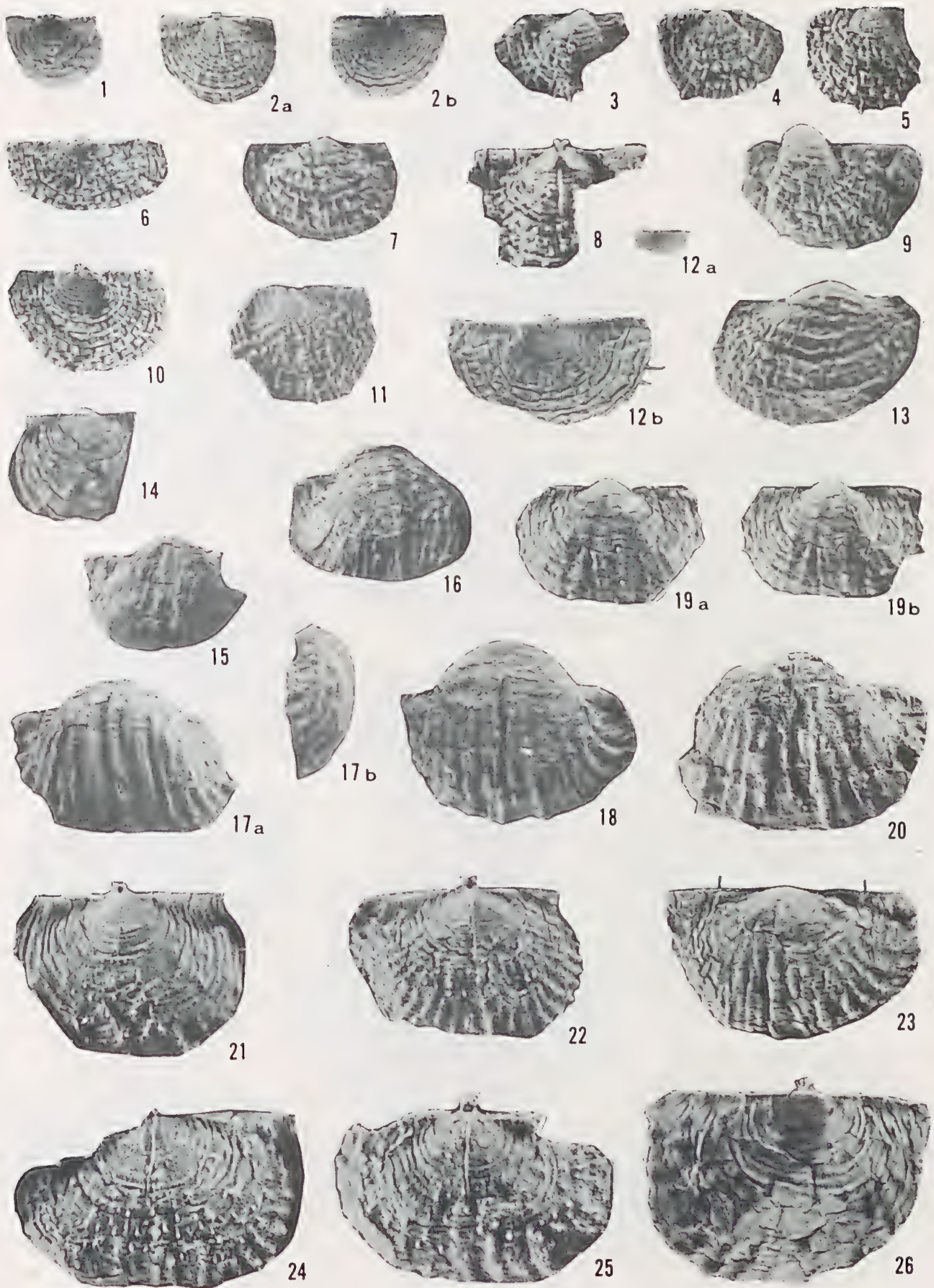


PLATE 7



#### EXPLANATION OF PLATE 8

FIGS 1-18. *Semiproductus etheridgei* sp. nov.

All specimens from W77 G.S.Q.

1. F11408 G.S.Q., natural mould of juvenile pedicle valve interior,  $\times 1.5$ .
2. F11406 G.S.Q., rubber cast of incomplete pedicle valve exterior, to show ornamentation of aurications,  $\times 1.5$ .
3. F11547 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 1.5$ .
4. F4089 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 4.5$ .
5. F11545 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 1.5$ .
6. F11405 G.S.Q., rubber cast of segment of pedicle valve exterior, to show ornament,  $\times 1.5$ .
7. F11549 G.S.Q., paratype, brachial valve; (a) rubber cast of exterior,  $\times 1.5$ ; (b) rubber cast of interior,  $\times 1.5$ .
8. F11550 G.S.Q., paratype, natural mould of brachial valve exterior,  $\times 1$ .
9. F4086 G.S.Q., paratype, natural mould of brachial valve exterior,  $\times 1$ .
10. F11551 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 1.5$ .
11. F11407 G.S.Q., paratype, natural mould of brachial valve exterior, and hinge spines of pedicle valve,  $\times 1.5$ .
12. F11324 G.S.Q., natural mould of brachial valve exterior, and hinge spines of pedicle valve,  $\times 1.5$ .
13. F11548 G.S.Q., paratype, brachial valve; (a) natural mould of exterior,  $\times 1.5$ ; (b) rubber cast of interior,  $\times 1.5$ .
14. F11546 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 1.5$ .
15. F4087 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 1.5$ .
16. F11544 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 1.5$ .
17. F11543 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 1.5$ .
18. F4088 G.S.Q., holotype, exterior of pedicle valve,  $\times 1.5$ .



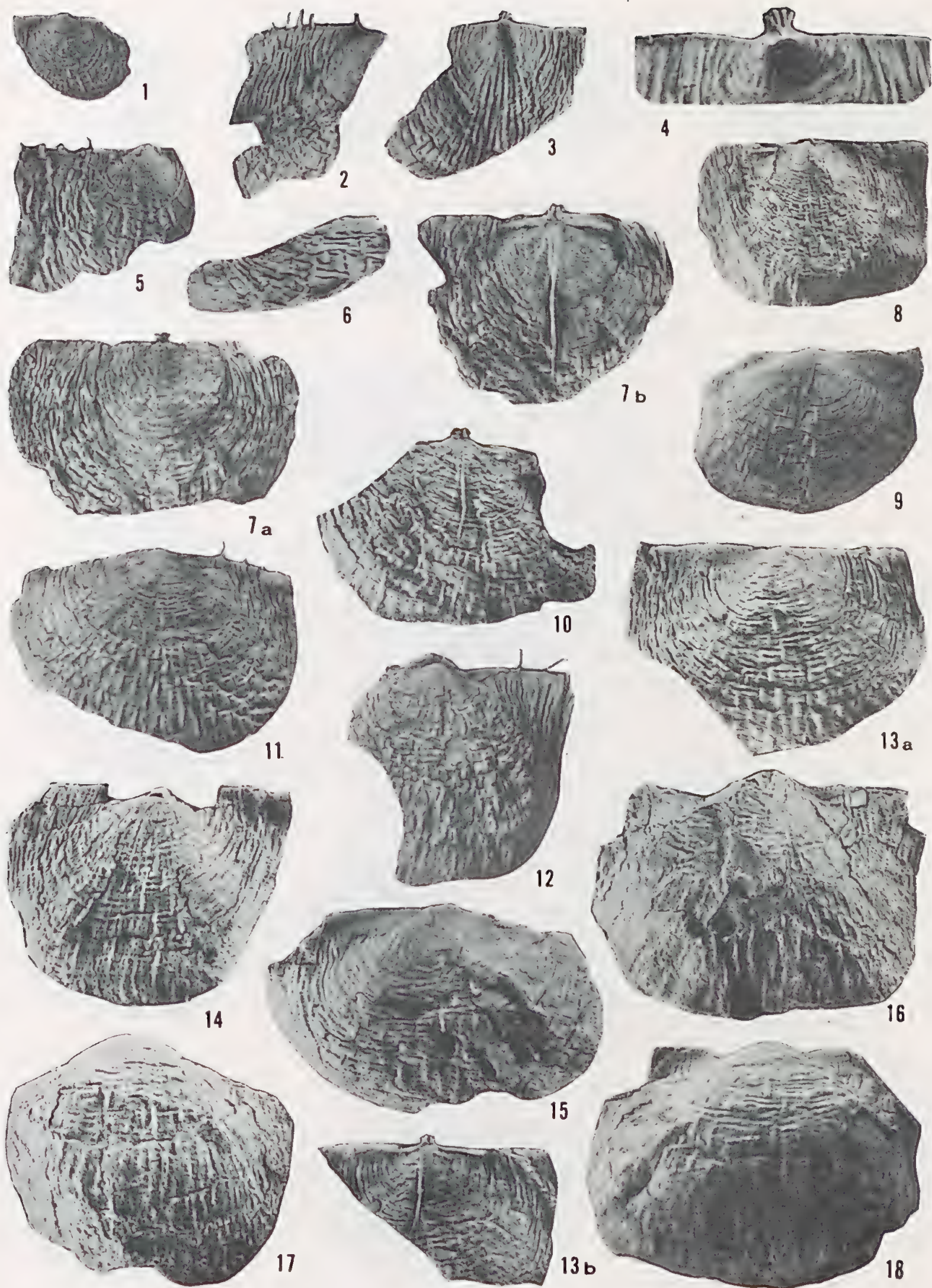


PLATE 8



#### EXPLANATION OF PLATE 9

FIGS 1-13. *Sentosia profunda* sp. nov.  
All specimens from W100 G.S.Q.

1. F11461 G.S.Q., rubber cast of juvenile pedicle valve exterior (incomplete),  $\times 2$ .
2. F11460 G.S.Q., rubber cast of incomplete pedicle valve exterior,  $\times 2$ .
3. F11449 G.S.Q., rubber cast of incomplete pedicle valve exterior,  $\times 2$ .
4. F11451 G.S.Q., paratype, rubber cast of incomplete pedicle valve exterior,  $\times 2$ .
5. F11446 G.S.Q., paratype, immature brachial valve; (a) rubber cast of interior,  $\times 2$ ; (b) rubber cast of exterior,  $\times 2$ .
6. F11465 G.S.Q., paratype, natural mould of immature pedicle valve interior,  $\times 1.5$ .
7. F11447 G.S.Q., paratype, rubber cast of juvenile brachial valve exterior,  $\times 3$ .
8. F11443 G.S.Q., rubber cast of brachial valve exterior,  $\times 1.5$ .
9. F11445 G.S.Q., paratype, pedicle valve; (a) natural mould of interior, ventral view,  $\times 1.5$ ; (b) the same, posterior view,  $\times 1$ ; (c) the same, left lateral view,  $\times 1.5$ .
10. F3667 G.S.Q., holotype, brachial valve; (a) rubber cast of exterior,  $\times 1.5$ ; (b) rubber cast of interior,  $\times 1.5$ .
11. F11442 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 2$ .
12. F3669 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 1.5$ .
13. F11452 G.S.Q., paratype, rubber cast of brachial valve exterior; note encrusting bryozoa,  $\times 2$ .

FIGS 14-15. *Sentosia transversa*? sp. nov.  
Specimens from L818 G.S.Q.

14. F11455 G.S.Q., rubber cast of brachial valve exterior,  $\times 1.5$ . Outline and concavity intermediate between *S. profunda* and *S. transversa*.
15. F11458 G.S.Q., rubber cast of brachial valve interior,  $\times 1.5$ . Note notch in front of cardinal process, endospines in median sector.

FIG. 16. *Semiproductus etheridgei* sp. nov.

16. F11552 G.S.Q., pedicle valve; (a) corroded shell and partly exposed natural mould of interior,  $\times 1.5$ ; (b) the same, left lateral view,  $\times 1.5$ ; (c) the same, posterior view,  $\times 1.5$ . L1058 G.S.Q.



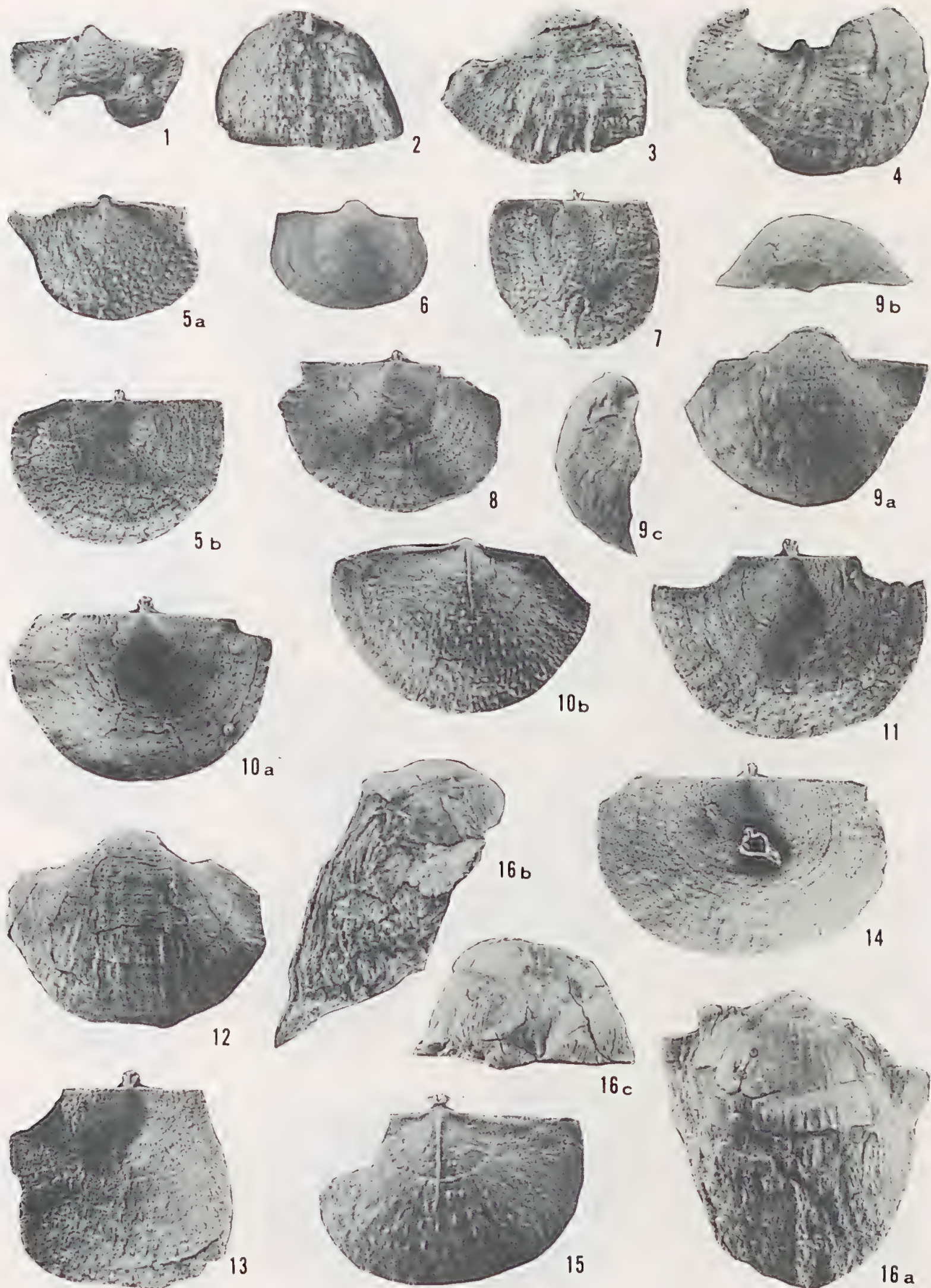


PLATE 9



#### EXPLANATION OF PLATE 10

Figs 1-11. *Sentosia minuta* sp. nov.

All specimens from W93 G.S.Q. = L1051 G.S.Q.

1. F3870 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 3$ .
2. F11518 G.S.Q., holotype, brachial valve; (a) rubber cast of interior,  $\times 3$ ; (b) rubber cast of exterior,  $\times 3$ .
3. F11528 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 3$ .
4. F3869 G.S.Q., paratype, rubber cast of incomplete brachial valve interior,  $\times 3$ .
5. F11525 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 3$ .
6. F11523 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 3$ .
7. F11522 G.S.Q., paratype, rubber cast of pedicle valve,  $\times 3$ . Anterior has composite internal/external features preserved.
8. F11438 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 3$ .
9. F11520 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 3$ .
10. F11521 G.S.Q., paratype, rubber cast of brachial valve exterior and umbonal region of pedicle valve,  $\times 3$ .
11. F11526 G.S.Q., paratype, brachial valve; (a) rubber cast of exterior,  $\times 3$ ; (b) natural mould of exterior,  $\times 3$ .

Figs 12-19. *Sentosia minuta deari* subsp. nov.

All specimens from L1994 U.Q.

12. F59052 U.Q., natural mould of pedicle valve interior,  $\times 1.5$ .
13. F59051 U.Q., natural mould of pedicle valve interior,  $\times 1.5$ .
14. F27261 U.Q., paratype, pedicle valve; (a) rubber cast of exterior,  $\times 1$ ; (b) the same,  $\times 2$ .
15. F27227 U.Q., paratype, natural mould of pedicle valve interior,  $\times 1.5$ .
16. F27254 U.Q., paratype, rubber cast of brachial valve interior,  $\times 1.5$ .
17. F27253 U.Q., holotype, rubber cast of brachial valve interior,  $\times 1.5$ .
18. F27259 U.Q., rubber cast of brachial valve exterior,  $\times 2$ .
19. F27260 U.Q., paratype, brachial valve; (a) rubber cast of exterior,  $\times 2$ ; (b) rubber cast of interior,  $\times 2$ .



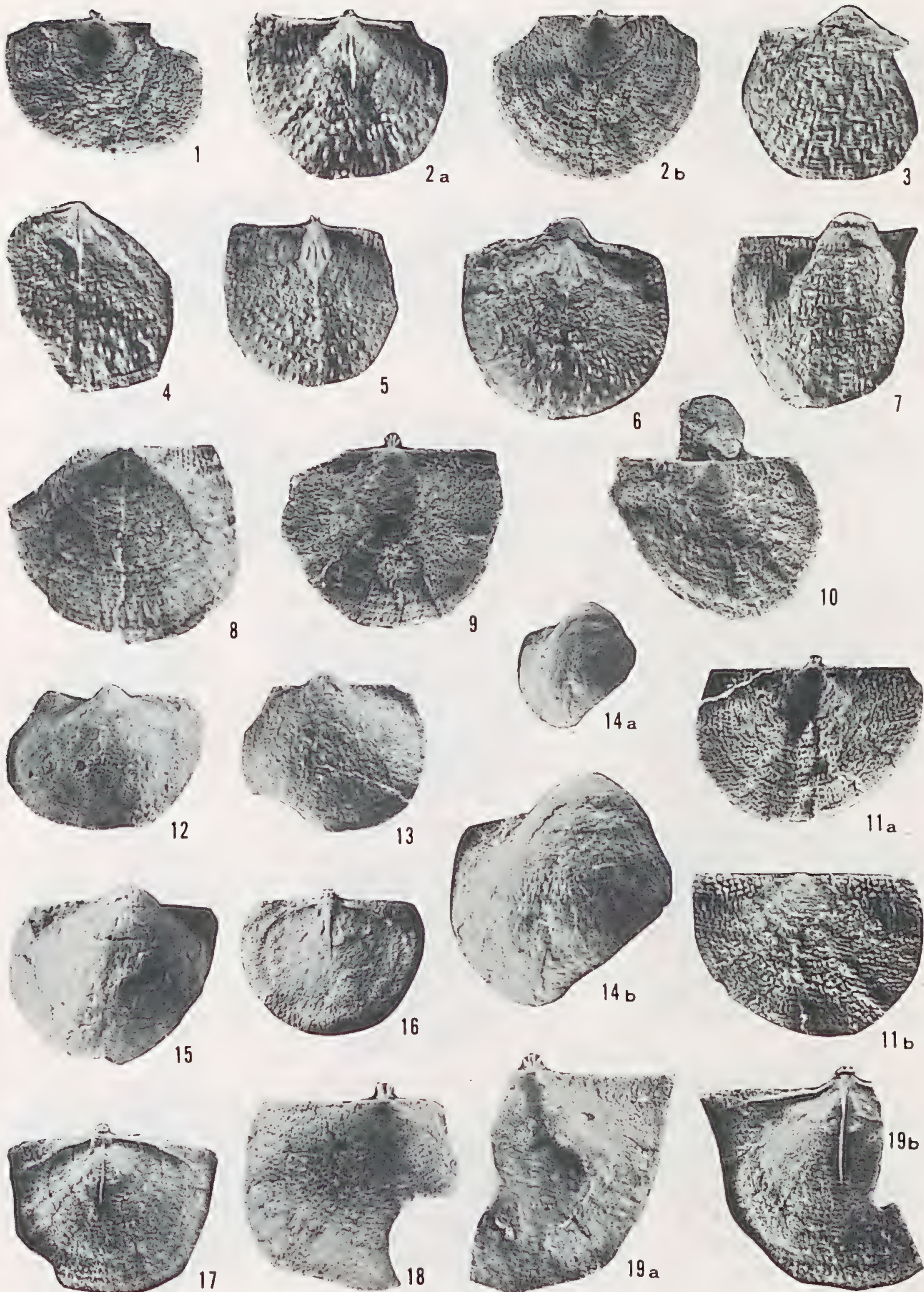


PLATE 10



#### EXPLANATION OF PLATE 11

FIGS 1-13. *Sentosia transversa* sp. nov.  
All specimens from L358 G.S.Q.

1. F11538 G.S.Q., paratype, rubber cast of immature brachial valve interior,  $\times 2$ .
2. F11533 G.S.Q., paratype; (a) rubber cast of brachial valve interior,  $\times 2$ ; (b) natural mould of brachial valve interior, and umbonal region of pedicle valve interior,  $\times 1.5$ .
3. F11532 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 2$ .
4. F11539 G.S.Q., paratype, brachial valve; (a) rubber cast of exterior,  $\times 1.5$ ; (b) rubber cast of interior,  $\times 2$ .
5. F11541 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 2$ .
6. F11542 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 2$ .
7. F5201 G.S.Q., holotype, pedicle valve; (a) rubber cast of exterior,  $\times 1$ ; (b) the same,  $\times 1.5$ .
8. F11534 G.S.Q., paratype, rubber cast of pedicle valve exterior,  $\times 1.5$ .
9. F11537 G.S.Q., paratype, rubber cast of pedicle valve exterior,  $\times 2$ .
10. F11529 G.S.Q., paratype, rubber cast of brachial valve exterior,  $\times 1.5$ .
11. F11536 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 1.5$ .
12. F11531 G.S.Q., paratype, natural mould of pedicle valve interior,  $\times 1.5$ .
13. F11540 G.S.Q., paratype, pedicle valve; (a) natural mould of interior,  $\times 1.5$ ; (b) rubber cast of exterior,  $\times 2$ .



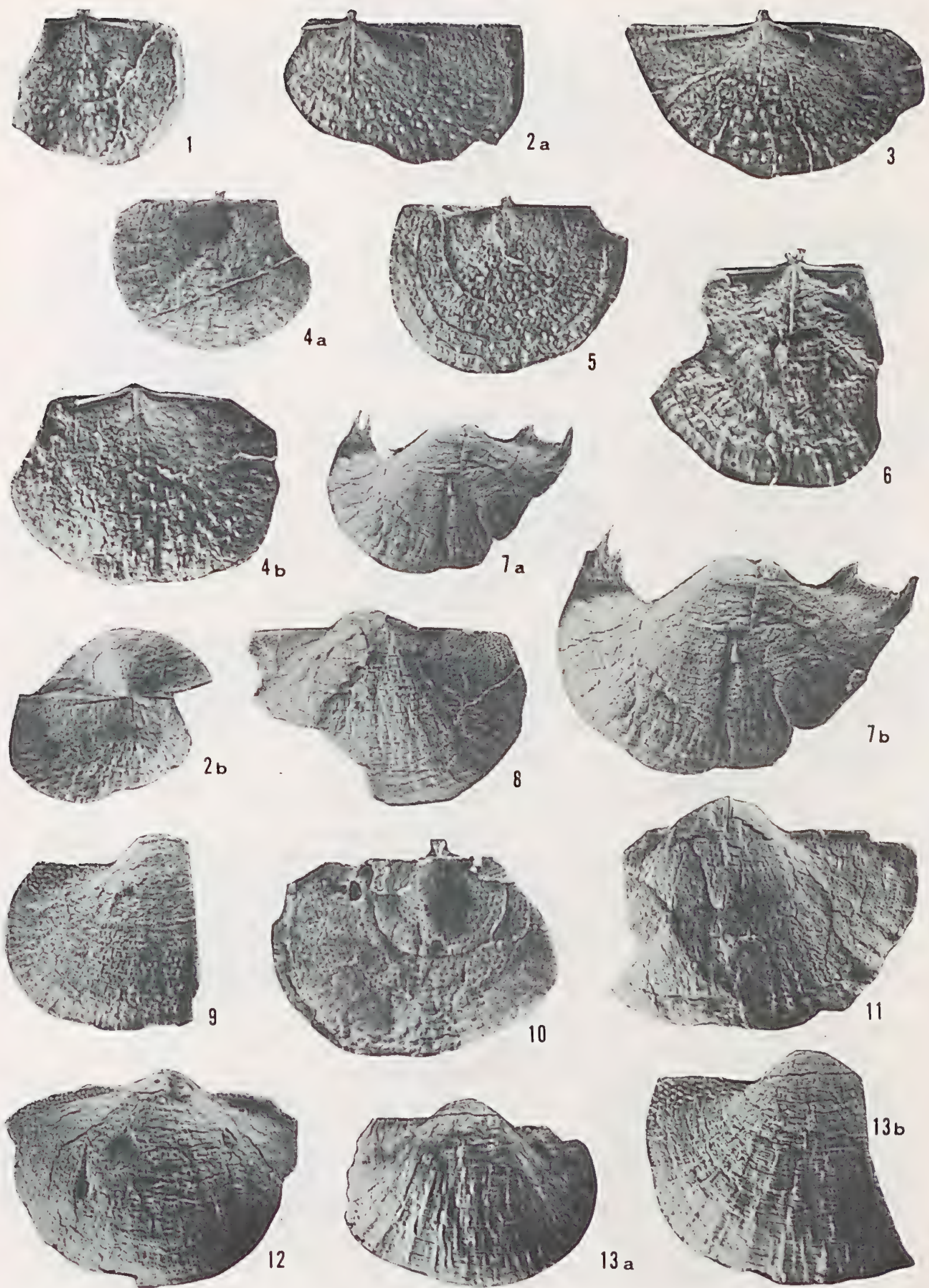


PLATE 11



## EXPLANATION OF PLATE 12

FIGS 1-7. *Sentosia plicata* sp. nov.

1. F3816 G.S.Q., holotype, natural mould of pedicle valve interior,  $\times 1$ . W102 G.S.Q.
2. F11459 G.S.Q., paratype, immature pedicle valve; (a) natural mould of interior,  $\times 1.5$ ; (b) rubber cast of incomplete exterior,  $\times 1.5$ . W102 G.S.Q.
3. F3728 G.S.Q., paratype, natural mould of immature pedicle valve interior,  $\times 1.5$ . L233 G.S.Q.
4. F3658 G.S.Q., paratype, rubber cast of brachial valve interior,  $\times 1.5$ . L233 G.S.Q.
5. F3656 G.S.Q., paratype, natural mould of brachial valve exterior,  $\times 1.5$ . W102 G.S.Q.
6. F11464 G.S.Q., paratype, natural mould of brachial valve exterior,  $\times 1.5$ . L233 G.S.Q.
7. F59386 U.Q., natural mould of brachial valve exterior,  $\times 1$ . L2251 U.Q.

FIGS 8-14. *Sentosia transversa caniensis* subsp. nov.

All specimens from D151 G.S.Q. = L2252 U.Q.

8. F10509 G.S.Q., holotype, pedicle valve; (a) natural mould of interior, posterior view,  $\times 1$ ; (b) the same, ventral view,  $\times 1$ .
9. F27270 U.Q., paratype, rubber cast of brachial valve exterior,  $\times 1$ .
10. F11454 G.S.Q., paratype, brachial valve; (a) rubber cast of interior,  $\times 1.5$ ; (b) rubber cast of exterior,  $\times 1.5$ ; (c) rubber cast of exterior, postero-dorsal view,  $\times 1.5$ .
11. F10510 G.S.Q., paratype, natural mould of brachial valve exterior,  $\times 1.5$ .
12. F27269 U.Q., paratype, pedicle valve; (a) natural mould of interior,  $\times 1.5$ ; (b) the same, right lateral view,  $\times 1.5$ .
13. F27268 U.Q., paratype, natural mould of pedicle valve interior, and brush of hinge spines,  $\times 1$ .
14. F27271 U.Q., natural mould of pedicle valve interior,  $\times 1.5$ .



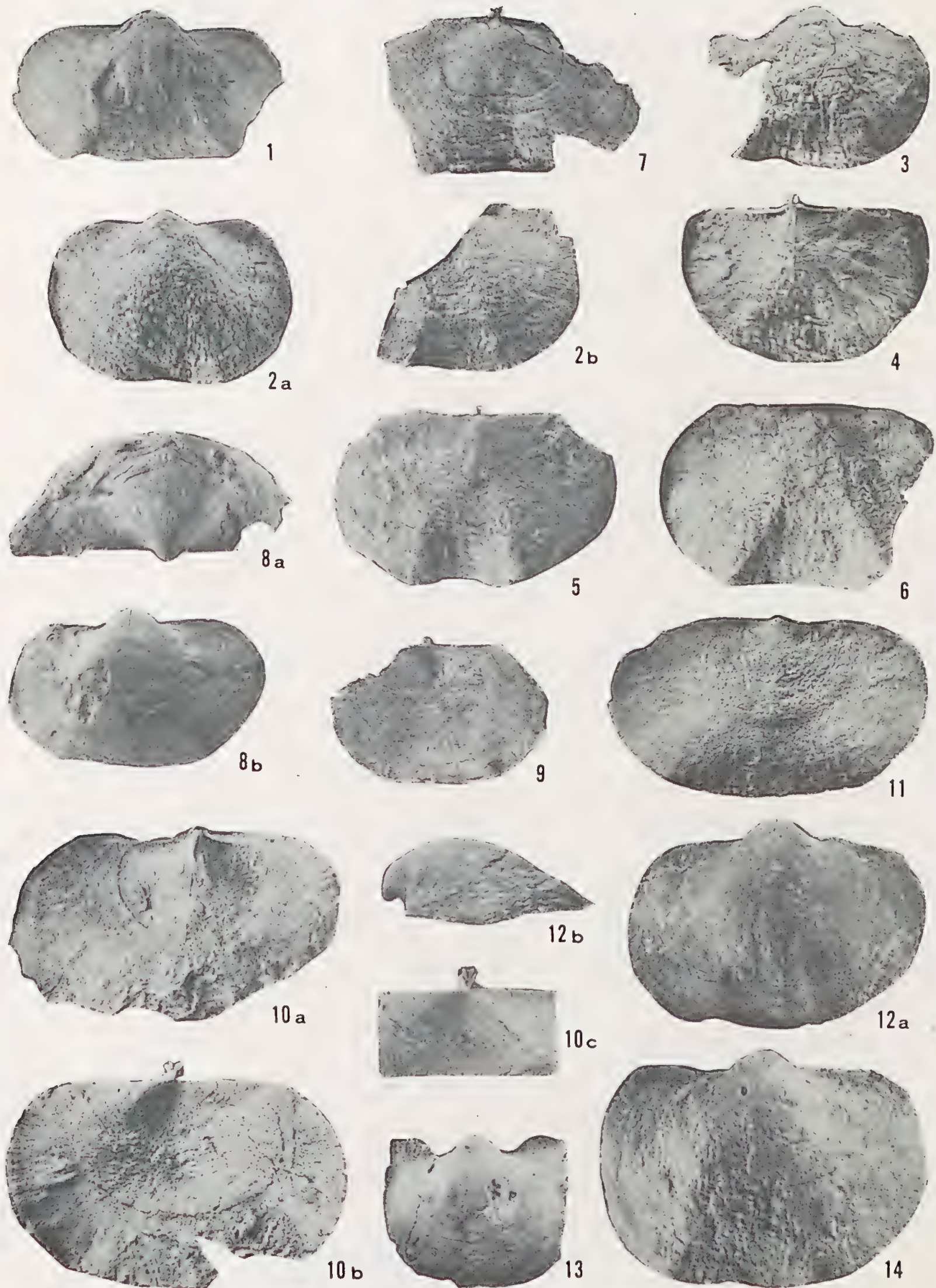


PLATE 12



















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GEOLOGICAL SURVEY OF QUEENSLAND  
(J. T. Woods, Chief Government Geologist)

PUBLICATION No. 343

THE PETROLOGY OF THE ULTRAMAFIC ROCKS  
OF THE ROCKHAMPTON DISTRICT,  
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## Figure 1





# THE PETROLOGY OF THE ULTRAMAFIC ROCKS OF THE ROCKHAMPTON DISTRICT, QUEENSLAND

C. G. MURRAY

GEOLOGICAL SURVEY OF QUEENSLAND\*

## ABSTRACT

Several bodies of ultramafic rocks outcrop in the Rockhampton area in Queensland. Harzburgite was originally the main rock type, but this has been serpentinitized to varying degrees. Typically the harzburgite contained about 75 per cent olivine (forsterite), 25 per cent orthopyroxene (enstatite), and a little diopside and spinel. Small amounts of dunite and pyroxenite were present.

Over most of their area, the ultramafic rocks have been completely serpentinitized. Both massive and schistose varieties of serpentinite occur. Massive serpentinites commonly retain the texture of the harzburgite. Schistose serpentinites are developed along some margins of the larger ultramafic bodies and throughout many of the smaller masses.

Hornfels of moderate grade are exposed at the margins of a number of ultramafic intrusions, and may represent contact metamorphic rocks formed during the emplacement of the ultramafics as harzburgites. The temperature indicated is about 700°C, requiring that the harzburgites were emplaced as largely crystalline bodies. Several ultramafic bodies were intruded as serpentinite in a solid state at relatively low temperatures.

The intrusion of serpentinite is believed to be a completely different process from the intrusion of harzburgite, and it is probable that these two events were separated by a considerable interval of time. For this reason it is difficult to establish the age of the Rockhampton ultramafic rocks.

## INTRODUCTION

This investigation of the ultramafic rocks of Central Queensland was commenced during regional mapping of the Rockhampton and Port Clinton 1:250,000 Sheet areas by a combined Bureau of Mineral Resources—Geological Survey of Queensland field party in 1965 and 1966. Subsequent laboratory studies included the examination of a large number of thin sections of the ultramafic rocks and their associates, and x-ray diffraction work on serpentine minerals and rocks. Further field work was carried out in 1968.

In this report, the nomenclature used for the ultramafic rocks is that of Williams, Turner and Gilbert (1954). The classification of the serpentine minerals is that given by Whittaker and Zussman (1956).

## REGIONAL GEOLOGY

The ultramafic intrusions of central and southern coastal Queensland are invariably associated with early Palaeozoic rocks of the Neranleigh-Fernvale Group or their equivalents. In the Rockhampton area, a tremendous thickness of these rocks (at least 60,000 feet) is present to the east of the ultramafics (Kirkegaard *et al.*, 1966), and represents an impressive geosynclinal development early in the history of the Tasman Geosyncline.

Ultramafic intrusions near Rockhampton lie along a fault system (the Yarrol Thrust) which separates these early Palaeozoic rocks from Devonian to Permian sediments and volcanics of the Yarrol Basin to the west (Hill, 1951; Kirkegaard and Dear, 1967). They generally occur as elongate bodies whose north-south to north-west-southeast strike is concordant with the strike of the enclosing rocks and with the dominant structural trend in the area, reflecting the overall trend of the Tasman Geosyncline (Wilkinson, 1953).

## DISTRIBUTION AND GEOGRAPHICAL FEATURES OF THE ULTRAMAFIC ROCKS

The distribution of the ultramafic rocks of the Rockhampton district is shown in Figure 1, adapted from preliminary geological maps of the St. Lawrence, Duarlinga, Rockhampton and Port Clinton 1:250,000 Sheet areas. Three large and several small masses are present.

The largest mass, about 25 miles long and up to 15 miles wide, outcrops between Marlborough and the Fitzroy River.

An elongate belt of ultramafic rocks extends discontinuously from near Mount Etna through Canoona and Glen Geddes and continues north-west past Kunwarara to a point about 3 miles south of Mount O'Connell. The total length of this belt is 35 miles, and its width is commonly less than 1 mile. From Glen Geddes an offshoot of the main mass extends north for 6 miles and forms the Pointers Range.

Another belt of serpentinite occurs further east between Balnagowan Homestead and Bondoola railway siding, having a length of about 25 miles and an average width of less than a mile.

Several small lenses of serpentinite intrude Lower Permian sediments and volcanics west of Canoona near Mona Vale and Edenbann Homesteads.

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Each of the three large masses of ultramafic rocks will be described separately; they will be referred to as the Marlborough mass, the Mount Etna-Glen Geddes-Kunwarara mass, and the Balnagowan-Cawarral-Bondoola mass.

Tertiary weathering produced siliceous and lateritic caps over large areas of the ultramafic bodies. Present day streams have eroded the ultramafic rocks to depths of a thousand feet below the Tertiary weathering surface, forming sharp-crested ridges. Outcrops of fresh serpentinized ultramafic rocks are confined to deep gullies.

Vegetation is dense where a lateritic profile is preserved. In other areas there is a moderate timber cover. The presence of numerous grass trees or blackboys (*Xanthorrhoea* sp.) and spinifex (*Triodia hostilis*) is typical of ultramafic outcrops.

### MARLBOROUGH MASS

#### Field relations

This mass extends over an area of more than 300 square miles from Edenbann Homestead to Marlborough, with an elongate extension north-west of Marlborough.

Originally harzburgite was the main rock type, but this has been serpentinized to varying degrees. Nearly all rocks examined contain a considerable percentage of pyroxene or bastite pseudomorphous after pyroxene. Serpentinized dunites are of limited extent, and are randomly distributed.

Two types of pyroxenite were observed. Completely serpentinized pyroxenite which was originally composed of enstatite occurs as scattered patches within the normal harzburgite. It is believed that these rocks represent segregations of enstatite crystals in the harzburgite. Pyroxenite composed of diopside is present at the northern margin of the intrusion. The diopside is fresh, and occurs as large crystal aggregates. Individual crystals are up to 1 foot long, and show diallage parting. These rocks are thought to occur as veins cutting the harzburgite. They resemble monopyroxenite veins described by Lauder (1965) from Dun Mountain in New Zealand.

The peripheral rocks of the intrusion have been completely serpentinized; partially serpentinized rocks occur towards the centre of the ultramafic body. However, within the centre, the distribution of serpentinized and partially serpentinized rocks is quite haphazard.

Most outcrops of partially serpentinized harzburgite are massive, but lineation of pyroxene crystals was observed at one locality 10 miles south of Marlborough (plate I, figures 1 and 2). The rocks in this vicinity also exhibit a distinct fissility, not apparent in hand specimens, but immediately obvious when the rocks are being broken. The fissility is more pronounced in rocks that are poor in pyroxene, and thus appears to be related to the orientation of olivine crystals.

At another locality a short distance to the east, pyroxene crystals form layers up to half an inch wide, with the crystals oriented at right angles to the layers. These layers are not continuous over large distances, but persist only for a few feet. The lack of any reasonably large continuous exposures makes it impossible to determine whether any large scale layering is present.

Many completely serpentinized rocks of this intrusion still retain the massive character of the original harzburgite. However, in places massive serpentinite is interspersed with schistose serpentinite consisting of un-sheared blocks up to several inches across surrounded by zones of sheared material. The schistose serpentinite appears to form belts with a general northwest-southeast trend. Schistose serpentinite has also been observed at the eastern edge of the ultramafic intrusion where it is faulted against low-grade muscovite schists, and at the margins of an inlier of similar schist.

The ultramafic rocks are intruded by dolerite dykes, gabbros, and a few small bodies of granite pegmatite. Basalt dykes are especially abundant towards the northern boundary of the intrusion. They have altered the serpentinite within a few inches of their contacts. No dykes were seen intruding partially serpentinized harzburgite.

At the south-eastern margin of the body, near Edenbann Homestead, the ultramafic rocks (which have been completely serpentinized) are intruded by a granodiorite stock. At the contact, the serpentinite has been converted into a fine-grained, homogeneous brown rock which is cut by many thin sub-parallel veins of magnesite and veins of pale green crystalline talc. This rock is too weathered for detailed examination.

#### Petrography

Hand specimens of the least serpentinized rocks from the intrusion are dark grey, with numerous pale green crystals of tabular pyroxene up to 10 mm long. Individual olivine crystals can be distinguished on a freshly cut surface because grain boundaries are marked by a network of magnetite granules.

Thin sections of these rocks are composed of about two-thirds unaltered olivine and pyroxene and one-third serpentine. Serpentine has formed along grain boundaries where it is accompanied by magnetite, and as irregular veins cutting individual grains. Typically, the original harzburgite contained about 75 per cent olivine, 25 per cent enstatite, and a little diopside and spinel.

Olivine occurs as rounded grains up to 7 mm in diameter. Some crystals show poorly defined deformation lamellae on (100), or undulatory extinction. The composition of the olivine, as determined by the method of Jackson (1960) revised by Hotz and Jackson (1963) is Fo<sub>92</sub> (forsterite).

Enstatite occurs as irregular prisms showing exsolution lamellae of Ca-rich pyroxene parallel to (100). Measurements of 2V on enstatite grains indicated an approximate composition of En<sub>91</sub> (Poldervaart, 1950).

Diopside and chrome spinel occur as relatively small grains. The spinel is brown or red-brown, usually with an opaque rim.

One thin section examined contains crystals of colourless amphibole in addition to partially serpentinized olivine, altered enstatite, and spinel. The amphibole appears to be a primary constituent of the harzburgite, and shows polysynthetic twinning. It is probably cumingtonite, which is known to replace orthopyroxene in the later stages of crystallization of gabbroic rocks (Deer, Howie, and Zussman, 1962, vol. 2, p. 245).



The harzburgite displays an undoubtedly igneous texture. Olivine crystals are equigranular, and their mutual boundaries are straight or gently curved. Some enstatite crystals contain inclusions of olivine. Inter-growths between spinel and olivine or pyroxene suggest an igneous origin (plate I, figure 3).

In the partially serpentinized harzburgites, magnetite occurs as granules which form discontinuous lines marking the original boundaries of olivine crystals (plate 1, figure 4). On each side of the magnetite is a thin band of serpentine with fibres at right angles to the band. The serpentinization process continued by growth inwards from the olivine grain boundaries.

The texture of the harzburgite is preserved in many completely serpentinized rocks. Original enstatite crystals can still be distinguished as dark green to black patches in a dull green or brown matrix.

This preservation of texture is very apparent in many thin sections (plate 1, figure 5). The mineralogy of the serpentinites is related to the mineralogy of the harzburgite in that each of the three primary minerals (olivine, enstatite, and diopside) gives a distinct product when serpentinized.

Olivine is typically replaced by mesh structure serpentine, in which grains of a brownish-green, nearly isotropic serpentine mineral (serpophite) are surrounded by rims of colourless material with a lower refractive index. In some cases the serpophite is semi-opaque.

Enstatite is always replaced by colourless bastite, which has a constant orientation throughout the entire replaced crystal.

Original grains of diopside are converted to a pale brown isotropic mineral of low refractive index.

The rocks are cut by veins of cross-fibre chrysotile asbestos. Magnetite and spinel are minor constituents of all the serpentinites; magnesite, tremolite, and chlorite are present in some specimens.

Not all the massive serpentinites consist of mesh structure serpentine and bastite. Two miles east of Marble Ridges Homestead, a mass of serpentinite surrounded by saussuritized gabbro has been recrystallized to antigorite. In thin section the antigorite appears as small, randomly oriented flakes. The texture of the harzburgite has been destroyed.

No schistose serpentinites from this intrusion were examined in detail.

#### Contact effects

At the northern margin, a thin zone of contact metamorphic rocks separates the ultramafic mass from an adamellite intrusion which extends south from Marlborough.

At a distance of about 200 yards from the ultramafic intrusion, the dominant rocks are banded amphibole hornfels. In thin sections, plagioclase (sodic labradorite) and dark green-brown amphibole are the chief minerals, and the banding is due to variations in the concentrations of these two constituents. Colourless diopside is scattered throughout the rock. Small amounts of quartz and opaque minerals are present.

As the ultramafic body is approached, the hornfels become finer-grained. The percentage of diopside increases, while those of amphibole, quartz, and opaque minerals decrease. Pale bands of labradorite and diopside alternate with dark bands of labradorite and amphibole, probably reflecting compositional variations in the source rocks. Rare crystals of sphene are present, and there are occasional relatively large grains of garnet in the diopside-rich bands. The banding of the hornfels is vertical, and parallels the margin of the ultramafics.

The actual contact of the hornfels with the ultramafic rocks was not observed during the present investigation, but is reported to be a sharp contact between hornfels and massive serpentinite (A. G. Kirkegaard, pers. comm.) It is considered that the contact metamorphic rocks were produced during the intrusion of the ultramafic rocks as harzburgite at a moderate temperature. This theory will be discussed later. The massive nature of the serpentinite suggests that serpentinization took place *in situ*. Veins of prehnite which cut the hornfels were presumably formed at some time during the serpentinization process.

South of the Fitzroy River near Edenbann Homestead, serpentinite contains large xenoliths of hornfels, consisting of green amphibole, plagioclase, and small grains of diopside. The xenoliths are cut by veins composed of plagioclase (andesine), prehnite, and epidote.

Contacts between serpentinite and muscovite schist are exposed in road cuttings on the north bank of the Fitzroy River west of Princhester Creek. The contact effects are similar to those which will be described later from exposures in cuttings on the road to the Princhester Microwave Station.

#### Age

It is difficult to determine the age of intrusion of this ultramafic body, since most contacts are faulted. Where definite intrusive contacts have been seen, they are with rocks of unknown (but probably early Palaeozoic) age.

The age of the granodiorite which intrudes massive serpentinite near Edenbann Homestead was determined as Lower Permian by radiometric dating methods (K-Ar date by A. W. Webb, Bureau of Mineral Resources, Canberra). The presence of talc and carbonate veins at the contact suggests that intrusion of the granodiorite took place after the serpentinization of the ultramafic rocks.

Thus a pre-Permian age is indicated for the emplacement of the original harzburgite.

### MOUNT ETNA-GLEN GEDDES-KUNWARARA MASS

#### Field relations

The belt of ultramafic rocks which extends from Mount Etna to Mount O'Connell appears to be a relatively thin sheet dipping to the east at a moderate angle. In cuttings on the road to the Princhester Microwave Station, the western contact with the enclosing schist and marble of the country rocks is well exposed, and dips to the east at about 30°. Further south, the contact is steeper. It is broadly parallel to the schistosity or bedding of the adjacent metamorphic, sedimentary, or volcanic rocks.



This body of ultramafic rocks is composed almost entirely of serpentinite, including both schistose and massive varieties. Schistose serpentinite is confined mainly to the western edge of the intrusion. At the eastern margin, the ultramafic rocks, although completely serpentinitized, are unshaped.

Harzburgite was originally the main rock type. Partially serpentinitized harzburgite occurs in the Pointers Range. The rocks are mainly massive, but discontinuous layers of pyroxene crystals similar to those in the Marlborough mass were observed. In the Pointers Range, a few specimens composed of coarsely crystalline green amphibole were collected. Their relation to the other ultramafic rocks is not known.

The ultramafic rocks are intruded by a number of small basaltic dykes and two bodies of saussuritized diallage gabbro in the vicinity of the Princhester Microwave Station.

Several small lenses of serpentinite intrude Lower Permian sediments west of Canoona near Edenbann and Mona Vale Homesteads. The smaller bodies consist entirely of schistose serpentinite, whereas the larger ones (up to half a mile long and 200 yards wide) have massive cores surrounded by schistose material. The structures and field relations of these serpentinite lenses indicate that they have been intruded at a low temperature in a solid state in response to tectonic movements. Some lenses have brecciated margins. The breccias consist of angular fragments of serpentinite set in a matrix of clay minerals, and differ from those described by Wilkinson (1953), in which both fragments and matrix are serpentinite.

### Petrography

Partially serpentinitized harzburgite from the Pointers Range 4 miles north-east of Glen Geddes is dark green to black, with pale green pyroxene crystals up to 10 mm in length. Examination of thin sections reveals that the rocks are similar to the partially serpentinitized harzburgite described earlier, and differ only in that they are serpentinitized to a greater degree (particularly the enstatite grains), and contain a greater proportion of diopside. The composition of the olivine is  $\text{Fo}_{93}$ .

Thin sections of the coarse amphibole aggregates from this locality show that colourless cummingtonite, exhibiting polysynthetic twinning, is the main constituent (plate 1, figure 6). Rare small grains of diopside are also present. Cummingtonite showing similar twinning was observed in one thin section of partially serpentinitized harzburgite from the Marlborough mass, and is believed to be a late stage primary constituent of the harzburgite.

Massive serpentinites from this ultramafic body are similar to those from the Marlborough area. Where weathered, they are pale brown, with a rough surface due to selective weathering of bastite pseudomorphs after pyroxene. Narrow veins of cross-fibre chrysotile asbestos traverse the serpentinites. Where these veins are numerous, they are always sub-parallel.

In these rocks, olivine is replaced by two serpentine minerals which form a mesh structure similar to that illustrated by Deer, Howie, and Zussman (1962, vol. 3,

p. 183). Enstatite is replaced by bastite. X-ray examination of bastite from serpentinite near Yaamba showed it to consist dominantly of lizardite. Spinel and magnetite are present in all the serpentinites. Magnesite, tremolite, chlorite, and anthophyllite have been observed in some specimens.

The schistose serpentinite has many of the features of the Vermont ultramafic rocks described by Chidester (1962). It consists of massive fragments up to several inches across surrounded by comparatively thin zones of apparently sheared serpentinite. The unshaped blocks are dark greenish black, whereas the sheared zones are pale green with a glossy lustre. Slickensides are common on shear planes, but do not define a consistent direction of movement. The massive fragments consist of irregularly oriented antigorite laths (plate 2, figure 1). Magnetite delineates boundaries of original olivine grains and cleavages of original pyroxene crystals (plate 2, figure 2). The pale green sheared zones are composed of slip-fibre chrysotile.

### Contact effects

Moderate to high-grade hornfelses can be seen along the eastern margin of the belt of ultramafic rocks between Glen Geddes and Kunwarara.

Contact metamorphic rocks are well exposed on the eastern slopes of Bonnie Doon Mountain, about 5 miles north-west of Glen Geddes. In the main these are amphibole hornfelses. The chief constituents are plagioclase (labradorite) and green-brown amphibole. In some specimens, clinopyroxene is present as small, equant grains.

In a railway cutting 4 miles north-west of Glen Geddes, massive black hornfels composed largely of calcic labradorite and clinopyroxene (probably salite) occurs as xenoliths in serpentinite. The clinopyroxene grains are strongly pleochroic from olive-green to yellow-brown. Magnetite, sphene, and garnet are minor constituents. Banded hornfelses of similar mineralogy outcrop west of the railway line. The banding is due to the differential concentration of light and dark minerals, and thin sections of the rocks exhibit a typical hornfelsic texture (plate 2, figure 3).

Some pyroxene hornfelses appear to have been derived from basic igneous rocks. In one thin section, two generations of pyroxene can be seen. Corroded, euhedral to subhedral crystals of colourless augite (some of which show slight zoning and faint hour-glass structure) are mantled by small, equant grains of pleochroic salite. The augite contains abundant dusty magnetite grains.

The mineralogy of other hornfelses, and relict structures which can be seen on weathered surfaces, suggest that the source rocks were sediments. In most cases these were rich in calcium, giving an assemblage labradorite-hornblende-magnetite-sphene or labradorite-diopside-garnet-magnetite-sphene. Two specimens of magnesium-rich hornfels were collected, containing a tremolite-spinel-forsterite-magnetite-chlorite assemblage. Chlorite appears to be a member of the metamorphic assemblage, but it also occurs in veins cutting the hornfels, together with hydrogarnet or vesuvianite. The spinel is a relatively pale green magnesian variety.



Although many of the amphibole bearing rocks show hornfelsic textures (plate 2, figure 4), others exhibit a strong foliation, which may be accompanied by a distinct lineation, revealing that the environment was not free of stress during recrystallization.

In the few places where it can be measured, the banding in the hornfels strikes northwest-southeast, parallel to the ultramafic belt, and dips steeply to the north-east. The contact of the ultramafic mass is thought to dip in the same direction, but at a shallower angle. The fact that moderate to high-grade hornfels are in contact with and included in massive serpentinite suggests that contact metamorphism of these rocks took place during the emplacement of the ultramafic rocks as harzburgite. Subsequently, the harzburgite was serpentinitized in situ.

There is considerable evidence for metasomatic alteration of the hornfels after their formation. Rodingites and epidote-diopside rocks which appear to have been derived from the normal metamorphics occur adjacent to serpentinite in some localities, and veins of prehnite and chlorite cut the hornfels. This alteration presumably occurred at the time of the serpentinitization of the ultramafic rocks.

North-west of Kunwarara, the hornfels at the eastern contact of the ultramafic mass retains sedimentary structures. These rocks contain abundant porphyroblasts of cordierite up to half an inch across. The cordierite shows both sector and polysynthetic twinning, and is crowded with inclusions of the other constituents. These include quartz and biotite, minor muscovite and plagioclase, and accessory tourmaline and apatite.

The small ultramafic mass which outcrops 3 miles south of Mount O'Connell is surrounded by an aureole of garnet-magnetite-clinopyroxene-plagioclase hornfels.

Contact effects along the western margin of this belt of ultramafic rocks are quite different from the effects described above from the eastern margin. Excellent exposures occur in cuttings on the road to the Princhester Microwave Station. The country rocks here are biotite-andesine-quartz schists and interbedded recrystallized limestones.

The serpentinite, which is quite massive further to the east, becomes progressively more sheared towards its margin, and for a distance of about 2 feet from the contact has been converted to a schistose rock composed of approximately equal amounts of chlorite and tremolite. Within 1 foot of the contact, the biotite schist has been altered to a black chlorite rock ("blackwall"). The blackwall is followed by a foot wide zone of dense, pale green rocks whose main constituents are epidote, tremolite, chlorite, and diopside. This zone is strongly jointed with the joints at right angles to the contact. These rocks grade outward to tremolite-bearing schists and thence to biotite schists at a distance of not more than 20 feet from the serpentinite. The contact is conformable with the schistosity of the country rocks.

Two serpentinite lenses 10 and 3 feet thick intrude schist at distances up to 200 yards from the main ultramafic body. Again, their contacts are conformable with the schistosity of the country rock, and the alteration produced at their margins is the same as that described above.

Basalt dykes which intrude the ultramafic rocks at this locality have in some cases undergone extensive metasomatic alteration. The dyke shown in plate 2, figure 5, has sharply defined black borders about an inch wide on either side of a pale green centre. The centre consists of epidote, diopside, and tremolite, while the borders, which are zoned parallel to the contacts of the dyke, are composed mainly of chlorite with needle-like prisms of white tremolite and disseminated grains of magnetite.

The low temperature metamorphism and metasomatism at this western contact are believed to have taken place during the emplacement of the ultramafic rocks as serpentinite in a solid state in response to tectonic forces. The distance of movement cannot have been large, because the original intrusive contact of the harzburgite is preserved at the eastern margin.

### Age

For the most part this body of ultramafics intrudes low-grade metamorphic rocks of possible early Palaeozoic age. The hornfels at the eastern contact cannot be correlated with any of the unmetamorphosed formations in the area.

Serpentinites west of Canoona and between Mount Etna and Yaamba intrude Lower Permian volcanics and sediments.

## BALNAGOWAN-CAWARRAL-BONDOOLA MASS

### Field relations and petrography

The ultramafic body between Balnagowan and Bondoola has been described by Wilkinson (1950). For most of its length it lies along a major fault (the Yarrol Thrust) separating Lower Permian volcanics to the west from early Palaeozoic sediments to the east. The fault plane dips to the east at a steep angle, and thus the ultramafic mass outcrops as a narrow belt trending roughly north-south. The ultramafic rocks have been completely serpentinitized.

Serpentinite exposed in cuttings along the Rockhampton-Emu Park road near Tungamull is a massive, mottled grey rock. Thin sections show that relatively coarse flakes of antigorite up to 1 mm long are the main constituent, with a few veins of chrysotile (plate 2, figure 6). Relict, pyroxene grains up to 8 mm long can be distinguished indicating that harzburgite was the source rock of the serpentinite.

Near Balnagowan and Mount Wheeler, schistose serpentinite is the main rock type.

Diallage gabbros intrude serpentinite north of Cawarral.

Calcium metasomatism which accompanied the serpentinitization process has produced unusual rock types within the serpentinite. A pale green, fine-grained rock from old chromite workings at Elgalla, south of Tungamull, consists almost entirely of vesuvianite.

A basalt dyke which intrudes the ultramafic rocks 2 miles south of Tungamull has been converted to a dark grey, fine-grained rodingite, in which original plagioclase prisms have been replaced by hydrogarnet.



### Contact effects

Between Cawarral and Tungamull, the contact rocks of the serpentinite are fine-grained, grey-green and consist of albite (as radiating acicular crystals), epidote, and calcite. These rocks are mineralogically similar to some of the metasomatically produced albitites described by Leonardos and Fyfe (1967) from California. In other areas the contact effects of the serpentinite are negligible.

### Age

The fact that the serpentinite marks the boundary between Lower Permian and early Palaeozoic rocks indicates that its last movement was post-Lower Permian. The trachyte plug of Mount Wheeler, north of Cawarral, which intrudes serpentinite is Upper Cretaceous in age.

## INTRUSION OF THE ULTRAMAFIC ROCKS

There are believed to be two distinct modes of intrusion of ultramafic rocks in the Rockhampton area.

Firstly, the original harzburgite bodies were emplaced at a moderate temperature. The metamorphic grade of hornfelses which are considered to have been formed during this intrusion reveals that the temperature at the contacts was about 700 °C. This is well above the stability range of serpentine minerals, and serpentization could not have commenced till the ultramafic mass began to cool. The contacts are characterized by massive serpentinite.

Following serpentization of the ultramafic rocks in situ, serpentinite was remobilized in some areas in response to tectonic forces and intruded in a solid state at a relatively low temperature. Contacts where this type of movement has taken place are characterized by schistose serpentinite, and the development of a narrow low temperature metamorphic and metasomatic alteration zone in the country rocks. Re-intrusion of serpentinite took place long after the initial emplacement of the harzburgite (cf. Thomas 1951; Leech, 1953).

## INTRUSION OF THE HARZBURGITES

For many years there has been conflict of opinion regarding the intrusion of ultramafic rocks (e.g. Hess, 1955, p. 401).

When examined in the field and under the microscope, many ultramafic rocks give every indication of having crystallized from a fluid magma. An example is the intrusive serpentinite described by Chesterman (1963).

The harzburgites of the Rockhampton area exhibit structures and textures typical of igneous rocks. At their margins they contain xenoliths of hornfels. Thin sections show that the rocks are equigranular, with igneous intergrowths between spinel and olivine or pyroxene (plate 1, figure 3). Some enstatite crystals contain inclusions of olivine grains. Lamellae parallel to (100) in olivine grains are often regarded as indications that the rocks have been subject to considerable stress after consolidation, but Brothers (1960) has suggested that in some New Zealand basalts such lamellae have formed in a magmatic environment.

Experimental investigations (Bowen and Schairer, 1936; Bowen and Tuttle, 1949) have shown that ultramafic magmas can only exist at high temperatures. Ito and Kennedy (1967) carried out a series of experiments on the melting of peridotite, and first detected liquid at a temperature of 1150 °C at 1 atmosphere pressure. The amount of liquid did not increase much with increasing temperature below 1400 °C, when it was still no more than 10 per cent. Recent work by Presnall (1966) suggests that at low pressures, peridotite can exist in a partly liquid state at about 1250 °C. Most intrusions of ultramafic rocks are not accompanied by the thermal metamorphic effects which should result from such temperatures.

A number of suggestions have been made to explain low temperature intrusion of peridotites. Hess (1938) postulated a hydrous peridotite magma which could exist at low temperatures. However, the experimental work of Bowen and Tuttle (1949) demonstrated that such a magma could not be formed below 1000 °C. Bowen suggested that ultramafic rocks are intruded in an almost solid state (Bowen, 1947; Bowen and Tuttle, 1949). A mass consisting mainly of olivine would move by means of flow in the crystalline state (translation gliding and granulation). If the body was serpentized, the physical properties of serpentinite are such that its intrusion would be greatly facilitated.

In recent years several high temperature peridotites have been recognized (Smith, 1958; MacKenzie, 1960; Smith and MacGregor, 1960; Green 1964a, b; Challis, 1965b).

Contact metamorphic rocks at the margins of some ultramafic bodies in the Rockhampton area are believed to have been produced during the emplacement of the ultramafics as harzburgite. Proof of this theory requires the examination of a complete contact aureole ranging from high-grade hornfelses near the ultramafic intrusion to unaffected country rocks. This is not possible because of the narrow width of the exposed metamorphic belts.

The metamorphic rocks belong to the hornblende-hornfels facies of Turner and Verhoogen (1960). Some possibly extend into the lower part of the pyroxene-hornfels facies. The temperature of recrystallization must have been about 700 °C. The extremely uniform grade of the hornfelses, their close association with the ultramafic rocks (similar contact metamorphic rocks do not occur elsewhere in the area), and the existence of sharp contacts between massive serpentinite and hornfels make it difficult to envisage any other origin for the metamorphics.

Small intrusions ranging in composition from granite to gabbro are common in the vicinity of the ultramafic rocks (see figure 1), but the contact metamorphic effects of these high level, post orogenic bodies are in all cases slight. There is no decrease in metamorphic grade away from these intrusions where they are adjacent to the contact aureole of the ultramafics.

The intrusion temperature of 700 °C indicated for the harzburgite eliminates the possibility that it was emplaced as a liquid magma. The actual mechanism of intrusion remains uncertain.

Challis (1965a) suggested that the Red Hills peridotite in New Zealand represents the ultramafic differentiates



of a basaltic magma. The Rockhampton rocks show no features indicative of such an origin. None of the constituent minerals occurs as euhedral or subhedral crystals. Also, the temperature of intrusion is too low for a gabbroic magma.

Several ultramafic bodies have been described, which are considered to have been emplaced as solid crystalline masses (MacKenzie, 1960; Smith and MacGregor, 1960; Ragan, 1963; Green, 1964b; Lipman, 1964; Burch, 1968). All show evidence of cataclastic recrystallization, including the presence of large strained relict porphyroclasts or augen enclosed in a fine-grained foliate groundmass. Such features contrast strongly with the equigranular, non-directed textures displayed by all specimens of harzburgites from the Rockhampton intrusions. Granulation of the primary constituents of the harzburgite was not observed in any of the thin sections examined during this investigation.

The features of the Rockhampton ultramafic rocks are most compatible with a theory of emplacement of the harzburgite as a crystal mush. This mode of intrusion has been envisaged for several gabbro-peridotite complexes (Flint *et al.*, 1948; Smith, 1958; Thayer, 1960, 1963). Flow-layering, foliation and lineation are usually developed in these rocks (Thayer, 1963). In the Rockhampton area, layering has been reported from the Pointers Range (geologists of The Broken Hill Co. Pty. Ltd., pers. comm.) and the fact that it has not been recognized more widely may be due to poor exposure and to the uniform nature of the ultramafic rocks. Layering in gabbro-peridotite complexes is best developed at contacts between gabbro and peridotite. Foliation and lineation in harzburgite have been noted at one locality at Rockhampton and careful study may show that they are common features throughout the intrusions.

It has already been pointed out that there is no possibility that an ultramafic mush can exist at a temperature of 700 °C. Olivine and pyroxene crystals must have been suspended in a less basic liquid which was removed during the last stages of emplacement of the harzburgite. The expulsion of this liquid may have been responsible for the formation of several small bodies of gabbro and pegmatite which outcrop within the area of ultramafic rocks.

### SERPENTINIZATION

Successive stages in the process of serpentinization can be observed in thin sections of the Rockhampton ultramafic rocks, and have been described earlier. Similar descriptions of the process are given by Lacroix (1942) and Roots (1954).

The susceptibility of the three primary minerals (olivine, enstatite, and diopside) to serpentinization seems to be variable. Wilkinson (1953) found relict orthopyroxene in some Queensland serpentinites, but no olivine. During the present investigation, olivine was found to be more resistant to serpentinization than enstatite. Relict olivine occurs in a number of specimens in which enstatite has been completely serpentinized. Diopside appears to be more resistant to serpentinization than either olivine or enstatite.

In many massive serpentinites from the Rockhampton area, the texture of the original harzburgite is perfectly

preserved. The network of magnetite granules which delineates olivine grain boundaries forms during the earliest stages of serpentinization (plate 1, figure 4). This network remains undisturbed in several completely serpentinized rocks (plate 1, figure 5; plate 2, figure 2). Complex intergrowths involving spinel are also preserved.

It is considered that this preservation of textures could only take place if volume increases during serpentinization were slight. Certainly the figure of 35 to 40 per cent volume increase suggested by Hostetler *et al.* (1966) seems to be incompatible with observations on the Rockhampton serpentinites.

Thayer (1966) gives similar evidence which indicates that serpentinization is not accompanied by significant increases in volume; and he attempts to show that appreciable changes in composition have taken place during serpentinization.

Since the least serpentinized rocks are found towards the centres of the largest intrusions, it is believed that the water required for serpentinization came from sources external to the ultramafic mass.

### Formation of antigorite

Serpentinization of the Rockhampton ultramafic rocks normally produced mesh structure serpentine and bastite (chrysotile and lizardite), but some serpentinites have been recrystallized to antigorite.

Recrystallization of massive serpentinites to antigorite is considered to have taken place during the intrusion of adjacent diagenetic gabbros. Antigorite flakes in these rocks are small (their average length is usually about 0.1 mm) and show a completely random orientation.

Antigorite is the dominant mineral in all the schistose serpentinites in the Rockhampton area. It is much coarser than in the massive varieties, and occurs as relatively large flakes (plate 2, figure 6). The sub-parallel orientation of the antigorite grains in some schistose serpentinites suggests the operation of shearing stresses, although massive fragments in these rocks appear unaffected by such stresses (plate 2, figure 2).

The evidence from the present investigation indicates that shearing aids the development of antigorite without being essential for its formation. There is some support for the views of both Wilkinson (1953), and Hess, Smith, and Dengo (1952). Wilkinson maintained that the formation of antigorite was dependent chiefly on thermal metamorphism, whereas Hess, Smith, and Dengo believed that shearing stress (accompanied by metamorphism of albite-epidote amphibole facies grade) was the main factor responsible.

Although antigorite differs slightly from the other serpentine minerals in composition (Faust and Fahey, 1962; Page, 1968) there is no relation between the composition or mineralogy of the original ultramafic rocks and the distribution of antigorite.

### INTRUSION OF THE SERPENTINITES

The intrusion of the serpentinites is here considered to be a separate and distinct process from that of intrusion of the harzburgites.



It is widely accepted that serpentinites can move in the solid state (cf. Chidester, 1962, p. 88). The experimental work of Raleigh and Paterson (1965) shows that although serpentinites have approximately the strength of granite at room temperature, they weaken appreciably at some temperature in the range 300 to 600 °C, when partial dehydration occurs. This dehydration also causes brittleness. Raleigh and Paterson conclude that in the temperature range mentioned, serpentinites move by brittle fracture and subsequent sliding on fracture surfaces. Because of the weakness of the serpentinite, only relatively low shear stresses are necessary to produce this effect. Brittle fracture will occur along a number of localized fracture zones. There is no general plastic deformation, and thus the original texture may be preserved. Partially serpentinitized peridotites show the same properties as serpentinites.

The features of the schistose serpentinites in the Rockhampton district can be explained by assuming that they were intruded in the manner suggested by Raleigh and Paterson.

The limited low temperature metamorphic and metasomatic effects at the contacts of these serpentinites are similar to those described by Coleman (1967). From the known stability fields of the metasomatic minerals, Coleman estimated the temperature at such contacts to lie between 250 and 500 °C, with high pressures.

#### AGE OF INTRUSION OF THE ULTRAMAFIC ROCKS

In the Rockhampton area there is evidence for two ages of intrusion of the ultramafic rocks. The initial event was the emplacement of a very large body of harzburgite at a moderate temperature. This was serpentinitized in situ,

and later remobilized in part in response to tectonic forces, at which time re-intrusion of some of the ultramafic rocks took place as solid serpentinite at a relatively low temperature.

No precise age can be determined for the intrusion of the harzburgite. Granodiorite which intrudes massive serpentinite near Edenbann Homestead was radiometrically dated as Lower Permian. Since the ultramafic rocks are considered to have been serpentinitized before the intrusion of the granodiorite, a pre-Permian age is suggested for the emplacement of the harzburgite. The harzburgite may have been emplaced during the Middle Devonian orogeny which formed the Yarrol Basin (Hill, 1951; Kirkegaard and Dear, 1967). Samples of amphibole hornfels from the contact aureole of the ultramafic rocks have been collected for radiometric dating, but no results have been received.

Lenses of serpentinite which intrude Lower Permian volcanics and sediments all have schistose margins, and were emplaced as solid serpentinite. Intrusion of these lenses is believed to have taken place during the Upper Permian orogeny, which ended marine sedimentation in the Yarrol Basin and folded the Palaeozoic rocks (Kirkegaard and Dear, 1967).

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Dr. Challis and Dr. Green read this report at an early stage and suggested several improvements.

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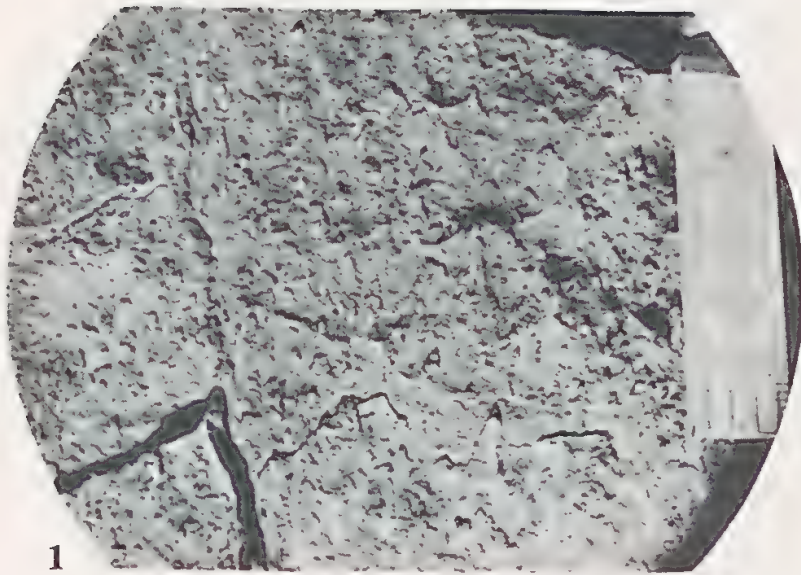
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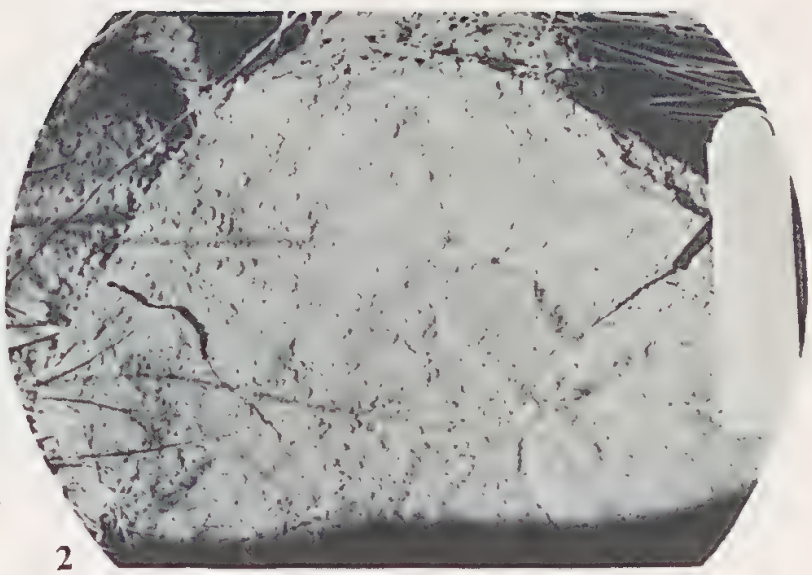
#### EXPLANATION OF PLATE 1

- Fig. 1 Partially serpentinized harzburgite showing lineation of enstatite crystals. Scale in inches.
- Fig. 2 Same specimen viewed parallel to the lineation.
- Fig. 3 Intergrowth between spinel and enstatite in partially serpentinized harzburgite. Plane light. X30.
- Fig. 4 Network of magnetite granules formed along olivine grain boundaries during the early stages of serpentinization of harzburgite. Plane light. X30.
- Fig. 5 Texture of harzburgite preserved in serpentinite. The boundaries of original enstatite crystals are delineated by magnetite granules. Plane light. X30.
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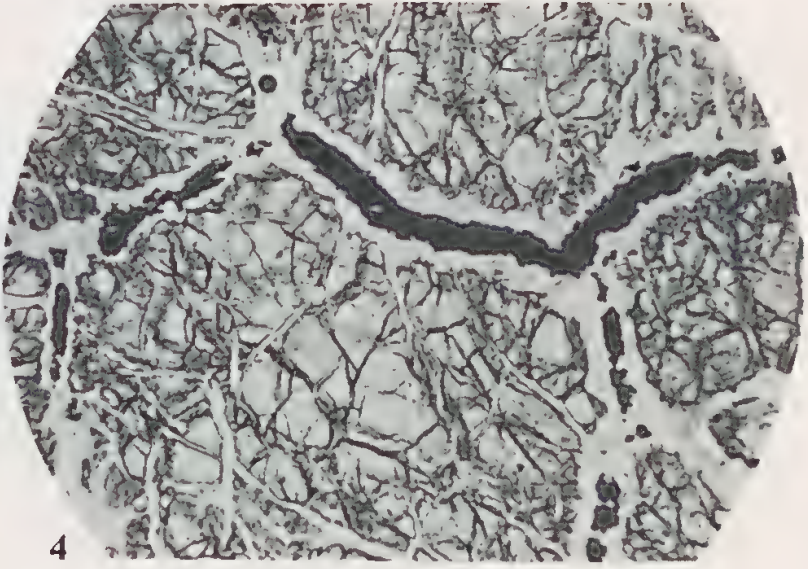
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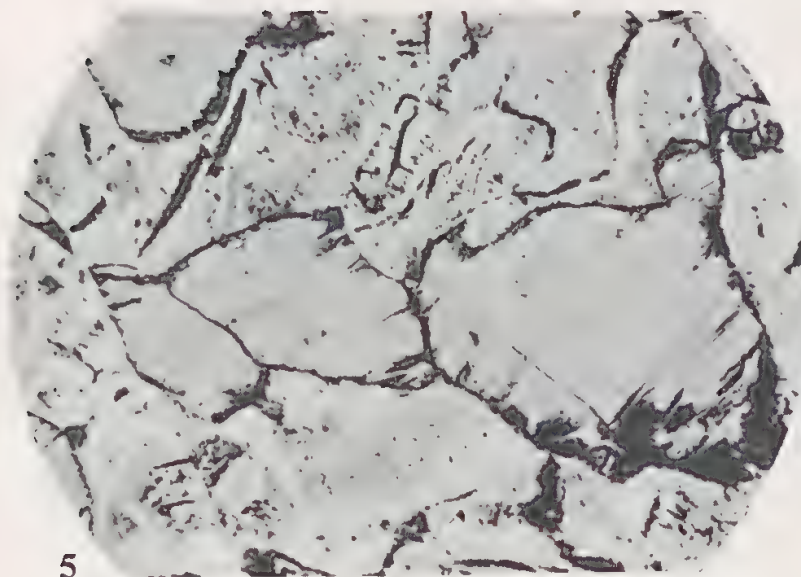
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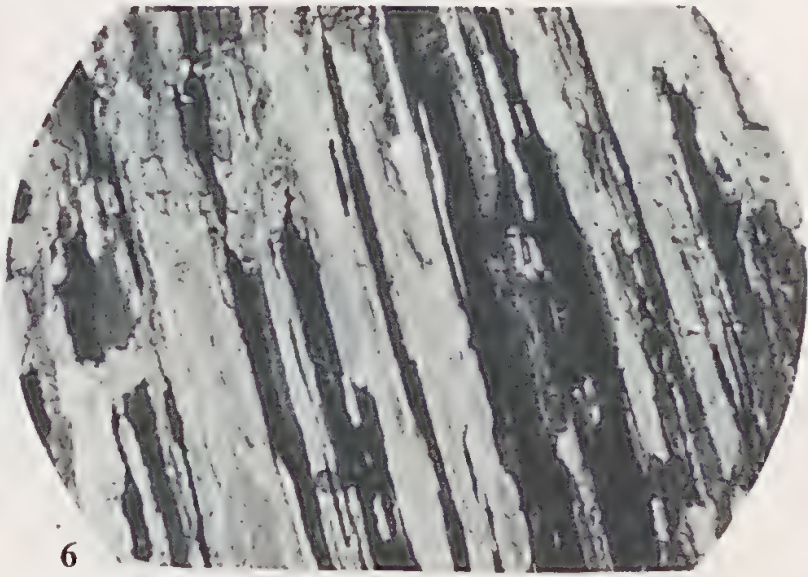
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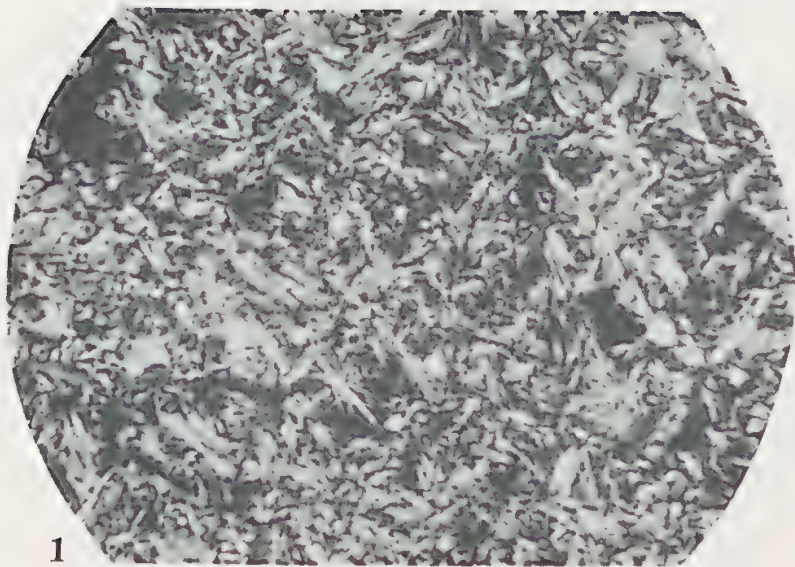
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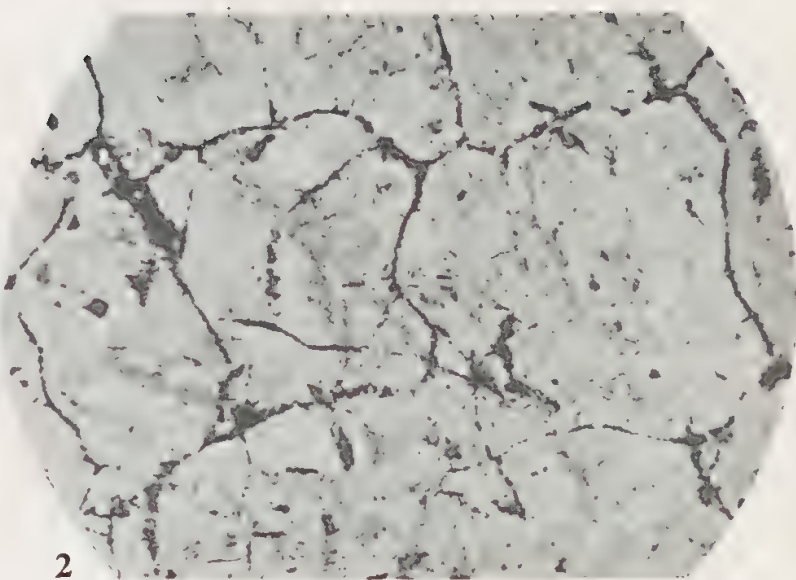
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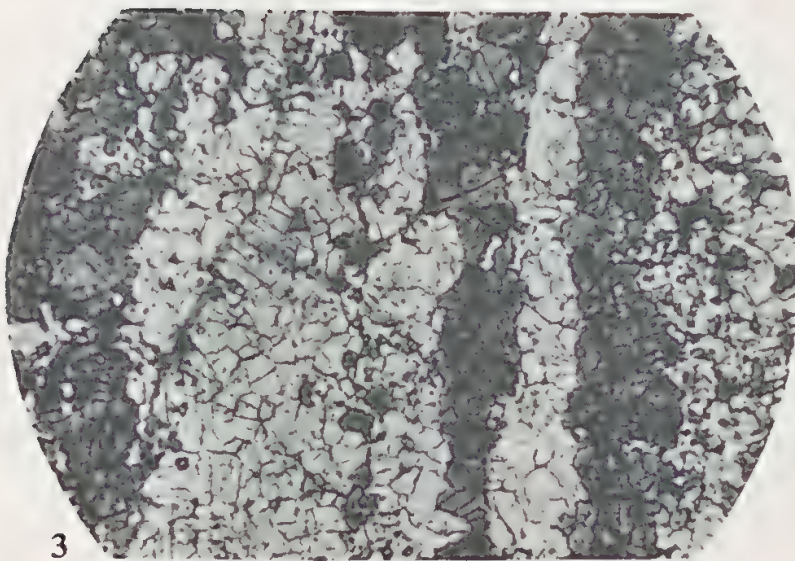




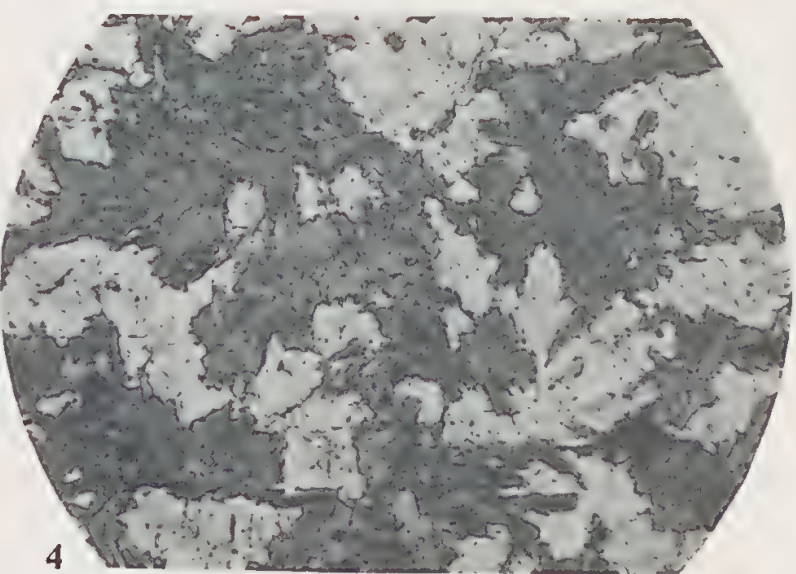
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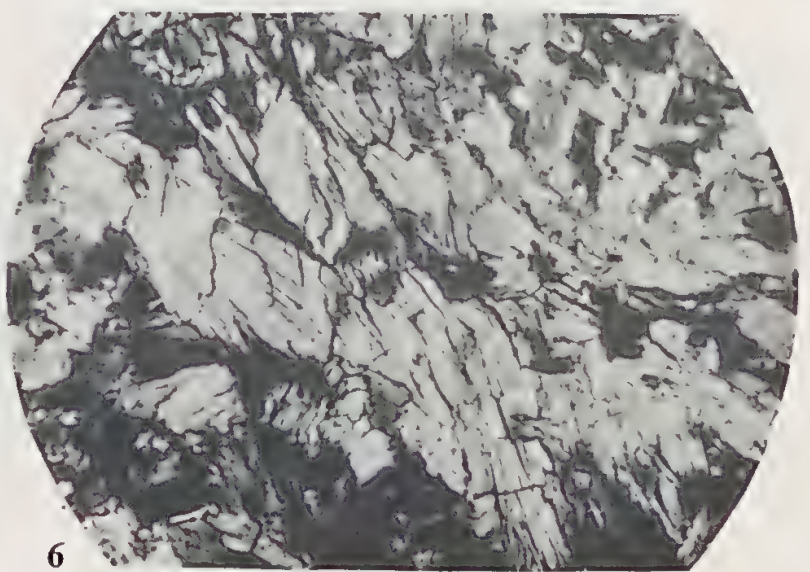
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QUEENSLAND  
DEPARTMENT OF MINES



GEOLOGICAL SURVEY OF QUEENSLAND  
(J. T. Woods, Chief Government Geologist)

PUBLICATION No. 344

# THE ROSEWOOD-WALLOON COALFIELD

by

J. B. CAMERON



By Authority. S. G. REID, Government Printer

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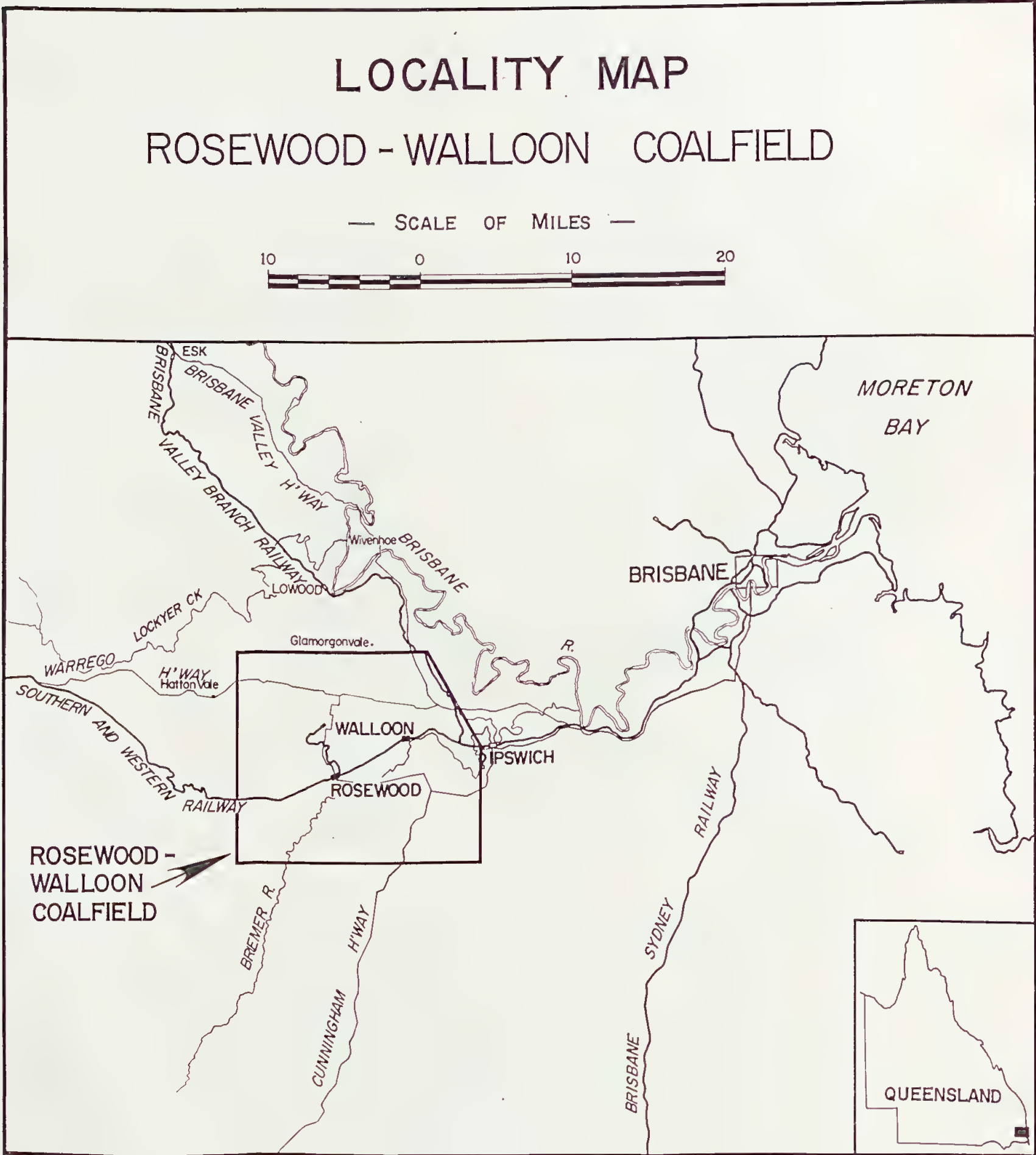
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FIG. I





## THE ROSEWOOD-WALLOON COALFIELD

by

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Geological Survey of Queensland

### ABSTRACT

In the Rosewood-Walloon Coalfield the coal-bearing beds are approximately 500 feet thick and comprise interbedded shales, siltstones, and fine-grained sandstones with eighteen persistent coal seams, all but one of which have been worked. This productive sequence is underlain by up to 90 feet of strata with similar gross lithology, but without coal seams and is overlain by at least 150 feet of massive, fine- and medium-grained sandstone. These three units constitute the Walloon Coal Measures of Middle Jurassic age. This formation overlies conformably the Lower Jurassic Marburg Formation, the uppermost beds of which comprise interbedded shales, siltstones and fine-, medium- and coarse-grained sandstones with pebbly layers. In places the Mesozoic rocks are overlain unconformably by up to 550 feet of Tertiary volcanics and sediments. In addition, large areas of the coalfield are blanketed by alluvial deposits of Quaternary age.

The coalfield is situated in the north-western part of the Moreton Basin in an area that has been subjected to only minor earth movements. The Mesozoic rocks have been folded into a shallow syncline which pitches gently to the south. Dips in excess of  $3^{\circ}$  are rare, except on the eastern limb, where under the influence of a zone of very steeply dipping strata further to the east dips as high as  $14^{\circ}$  occur.

Coal from the Walloon Coal Measures occurs in the range High Volatile A to High Volatile B Bituminous (ASTM classification). Hydrogen content (dry mineral-matter-free basis) is 6.3 per cent.; in consequence the coal on carbonization gives high yields of tar. In the past, the coal has been used for steam raising and the manufacture of town gas. With the loss now of most of these markets, future prospects for the coalfield are not good. In these circumstances the limited virgin coal reserves for the field of 5.9 million tons are considered adequate.

### INTRODUCTION

After the pioneering work of Reid (1921, 1922a, 1927) a quarter of a century was to elapse before any further significant geological work was undertaken in the Rosewood-Walloon Coalfield (see fig. 1 for location). In 1951 the Geological Survey began a systematic investigation of the collieries of the Perry's Knob area and subsequently diamond core drilling was recommended to prove reserves of coal in the Roughrigg and Malabar mine areas. This recommendation was put into effect early in 1952 when the Department of Mines commenced a programme of exploratory diamond drilling ahead of Roughrigg No. 7 Colliery. In the following ten years, this form of coal exploration was extended to all the producing collieries of the coalfield.

Diamond drilling was carried out in 21 mine areas, which can be grouped geographically into four separated districts: Rosewood-Haigslea (embracing fifteen mine areas), Amberley (four), Ebenezer and

the Bluff (one each). The total number of holes drilled was 246, the aggregate footage being 65,000 feet, of which almost 20,000 feet was drilled by non-coring methods. All core recovered, totalling some 42,000 feet and representing approximately 45,000 feet of strata, was logged in detail by geologists of the Geological Survey. Concurrently with the diamond drilling, underground geological inspections were made of all the producing collieries; particular attention was paid to the measurement of stratigraphic sections and the study of coal seam behaviour. With this abundance of geological data available, seam correlation was readily attained by the application of normal stratigraphic methods. As drilling progressed, the geology and coal resources of the individual mine areas were described in a series of reports by Hawthorne (1954a-b), Cameron (1956, 1959, 1960b, 1961a-c, 1962a-d, 1963a-h), and Chiu Chong (1962, 1963a-d).



In the years 1962 to 1964 considerably more detailed stratigraphic studies were made than were possible during the drilling period, when the emphasis was on the assessment of coal resources and, as a result, coal seam correlation was established over all the area tested by diamond drilling, some 30 square miles in all. However, it has been possible to extend seam correlation to only a few of the long abandoned collieries situated outside the drilled area, for most of these old mines were worked during the years 1927 to 1951, when very little reliable geological information was recorded. Collieries to which seam correlation has not been extended are listed in Table I.

This report co-ordinates and summarizes the wealth of geological information collected during the decade of intensive exploration from 1952 to 1961 and, incorporating as it does the findings of more detailed investigations in the years 1962 to 1964, presents the first comprehensive account of the geology and coal resources of the Rosewood-Walloon Coalfield since Reid's work over forty years ago. Its major contribution is the establishment of an accurate stratigraphic column of the Walloon Coal Measures in the type area. Within this formation, a total of eighteen coal seams, all but one of which have been worked, has been recognized and named on a coalfield-wide basis.

The writer has been associated with this project since 1953 and, for the greater part of the time, has been responsible for its geological supervision and the assessment of results obtained. In the preparation of this report, the work of various officers of the Geological Survey, both past and present, has been drawn on, and acknowledgement is made here of their contribution. In this regard, the work of Messrs Hawthorne and Chiu Chong warrants special mention. Thanks are extended to the owners, managers, and staff of all of the collieries on the coalfield and to the Inspectors of Mines, Booval, for their ready help and co-operation at all times.

TABLE I

## ROSEWOOD-WALLOON COALFIELD

Collieries to which seam correlation has not been extended—

| Colliery                                                                                                                                                                                                                                                                               | District           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| Duckenfield No. 2 .. .. .                                                                                                                                                                                                                                                              | Kunkala            |
| Pine Grove .. .. .                                                                                                                                                                                                                                                                     | Perry's Knob       |
| Commonwealth<br>Clarefield No. 1<br>Morland's<br>Old Rosewood<br>Smithfield No. 1                                                                                                                                                                                                      | Rosewood-Thagoona  |
| Rosemount No. 2 .. .. .<br>(previously Clayfield and Bradfield)<br>Rosemount No. 3                                                                                                                                                                                                     | Ebenezer           |
| Clarefield No. 2 .. .. .<br>Clarefield No. 3<br>Clydebank No. 2<br>Clydebank No. 3<br>Clydebank No. 4<br>Gowrie Fern<br>Moorefield No. 1<br>Moorefield No. 2<br>New Hope No. 1<br>(previously Clydebank No. 1)<br>New Hope No. 2<br>New Hope No. 3<br>Old Walloon<br>Orient<br>Walloon | Walloon            |
| Blue Bell .. .. .<br>New Westvale<br>(previously Westvale No. 1, Good Hope<br>and Yahmahnto)<br>Noblevale No. 7 (previously Purga)<br>Speedwell<br>Thistle No. 1<br>Thistle No. 2                                                                                                      | Loamside-Hampstead |

## GEOLOGICAL SUCCESSION

The geological formations outcropping in the Rosewood-Walloon Coalfield range from Mesozoic to Cainozoic in age. The succession is summarized in Table II.

## MESOZOIC

Although Gregory (1879) recognized that there were within the coal-bearing beds of the West Moreton district a lower and upper sequence, each characterized by a different coal type, it was Cameron (1905) who first subdivided the Mesozoic rocks. He showed that the lower and upper coal measures were separated by a considerable thickness of unproductive sandstone and to these three units he gave the names in ascending order, Ipswich, Bundamba, and Walloon Beds (Cameron, 1907).

In his first report on the Rosewood-Walloon Coalfield, Reid (1921) accepted Cameron's (1907) mapping to the west of Ipswich and so included in the Walloon "Series" (he also used the term Walloon Coal Measures) not only the coal-bearing beds in the vicinity of Walloon and Rosewood but also the underlying apparently unproductive sandstone sequence outcropping at Marburg and further north. These units he named the Rosewood "Stage" and the Marburg "Stage" respectively. In the following year when his report was reprinted, Reid (1922a) revised this classification placing the Marburg "Stage" in the Bundamba "Series". At that time Reid's usage of the term Bundamba "Series" was in keeping with Reid and Morton's (1922) interpretation of the geology of the area to the west of Ipswich and so was markedly different from Cameron's original definition. It must



TABLE II  
GEOLOGICAL SUCCESSION IN ROSEWOOD-WALLOON  
COALFIELD

| Era         | Period        | Formation                  | Lithology                                                                                                                                                                              | Thickness  |
|-------------|---------------|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Cainozoic   | Quaternary .. | Alluvium .. ..             | Black clay, sand, gravel .. ..                                                                                                                                                         | Ft.<br>100 |
|             | Tertiary ..   | Volcanics and Sediments .. | Basalt, magnesian limestone, mudstone, sandstone, pebble and boulder conglomerate                                                                                                      | 550        |
| Mesozoic .. | Jurassic      | <i>Unconformity</i>        |                                                                                                                                                                                        |            |
|             |               | Walloon Coal Measures ..   | Shale, siltstone, fine to medium-grained argillaceous and calcareous sandstone, cone-in-cone limestone, clay ironstone, coal seams                                                     | 750        |
|             |               | Marburg Formation .. ..    | Shale, siltstone, fine to medium-grained argillaceous and calcareous sandstone, coarse-grained pebbly quartzose sandstone, pebble conglomerate, cone-in-cone limestone, clay ironstone | *480       |

\* This figure applies only to that part of the unit examined and not to the formation as a whole.

be realized, however, that when Reid and Morton (1924) subsequently retracted their earlier views on the geological structure of that area and accepted Cameron's conception of the unit they still considered the beds mapped by Reid as the Marburg "Stage" were part of the Bundamba and not, as Cameron's (1923) Ipswich Coalfield Map No. 1 portrayed, part of the Walloon "Series". Reid and Morton then applied the name Walloon "Series" to the coal-bearing beds only, discarding on the grounds of priority Reid's later term Rosewood "Stage".

These views, however, were not accepted by Denmead (1955) who used the term Walloon "Series" in the sense of Reid (1921) to include both the Marburg and Rosewood "Stages". Further, Denmead considered that there was an unconformable junction between the Bundamba and Walloon "Series" and that, in the area to the west of Ipswich, the Marburg "Stage" was not represented. A similar but somewhat less specific opinion was expressed by Whitehouse (1955); he stated that in the area where Cameron first separated the Bundamba and Walloon Beds there was "a break in sequence between the two ... formations" and that, further west, this interval was represented by Reid's Marburg "Stage". In Whitehouse's opinion, the latter unit was not part of Cameron's Bundamba "Series" and, as it had sufficient individuality to be distinguished from the overlying coal-bearing beds, he proposed that it be considered a separate formation—the Marburg Formation. Whitehouse then revived Reid's alternative name of Walloon Coal Measures, which he used in preference to the term Walloon "Series" to describe only the coal-bearing beds (Reid's Rosewood "Stage"); this, Whitehouse argued, was Cameron's original intention. Continuing his general nomenclatural revision, Whitehouse referred to the Bundamba "Series" as the Bundamba Group although in the type area he did not recognize any constituent formations.

Although Denmead and Whitehouse both rejected Reid and Morton's (1924) interpretation of the relationship between the Bundamba "Series" and the Marburg "Stage", the views of these earlier workers have recently again found favour. As a result of his work to the south and west of Ipswich, Wilson (1960) subdivided the Bundamba "Series" into two major units, the lower of which he called the Bundamba Group and the upper he equated with the Marburg Formation. Likewise, McTaggart (1963a) correlated his redefined Marburg Formation in the Lockyer-Marburg district with the upper members of Cameron's Bundamba Beds and advocated that the term Bundamba Formation be used to describe only that part of the sequence underlying the suggested Marburg Formation equivalents. Unfortunately, this restricted use of the term Bundamba by both Wilson and McTaggart is in conflict with Cameron's original usage, a fact realized by the latter author when, in a subsequent paper (McTaggart, 1963b), he included the Marburg Formation in the Bundamba Group. This later interpretation was also adopted by Staines (1964). More recently Jorgenson and Barton (1966), as a result of their photogeologic study of the Ipswich Basin and Esk Trough, have also equated the Marburg Formation with the upper part of Cameron's Bundamba Beds.

It is evident from the widely divergent opinions summarized above that the exact stratigraphic relationship between the Bundamba and Marburg sequences has not yet been established. Final resolution of this problem must await the completion of far more detailed geological work in the structurally complex region between the two type areas. Consequently, in describing the geological succession in the area investigated, an objective approach as regards the nomenclature of the Mesozoic rock units has been adopted. The names Marburg Formation and Walloon Coal Measures, which have been used by all recent workers



in the Rosewood-Walloon Coalfield and so are now well established, have been accepted to describe the underlying coarser-grained unproductive sequence and the finer-grained coal-bearing beds respectively.

### MARBURG FORMATION

#### STRATIGRAPHIC COLUMN

The base of the Marburg Sandstone was first defined by Swindon (1960). McTaggart (1963a) extended the lower limit of the formation to include two additional members, which Swindon had not distinguished, but had included in the underlying Wivenhoe Sandstone. As redefined by McTaggart, the Marburg Formation is 1,400 feet thick, and "divisible into a lower caliche section and an upper siliceous section, the former comprising three stratigraphic members and the latter, one". During the present investigation of the Rosewood-Walloon Coalfield, only the top few hundred feet were examined; the relationship of these strata to the topmost beds of McTaggart's "upper siliceous section" or Heifer Creek Sandstone Member has not been established.

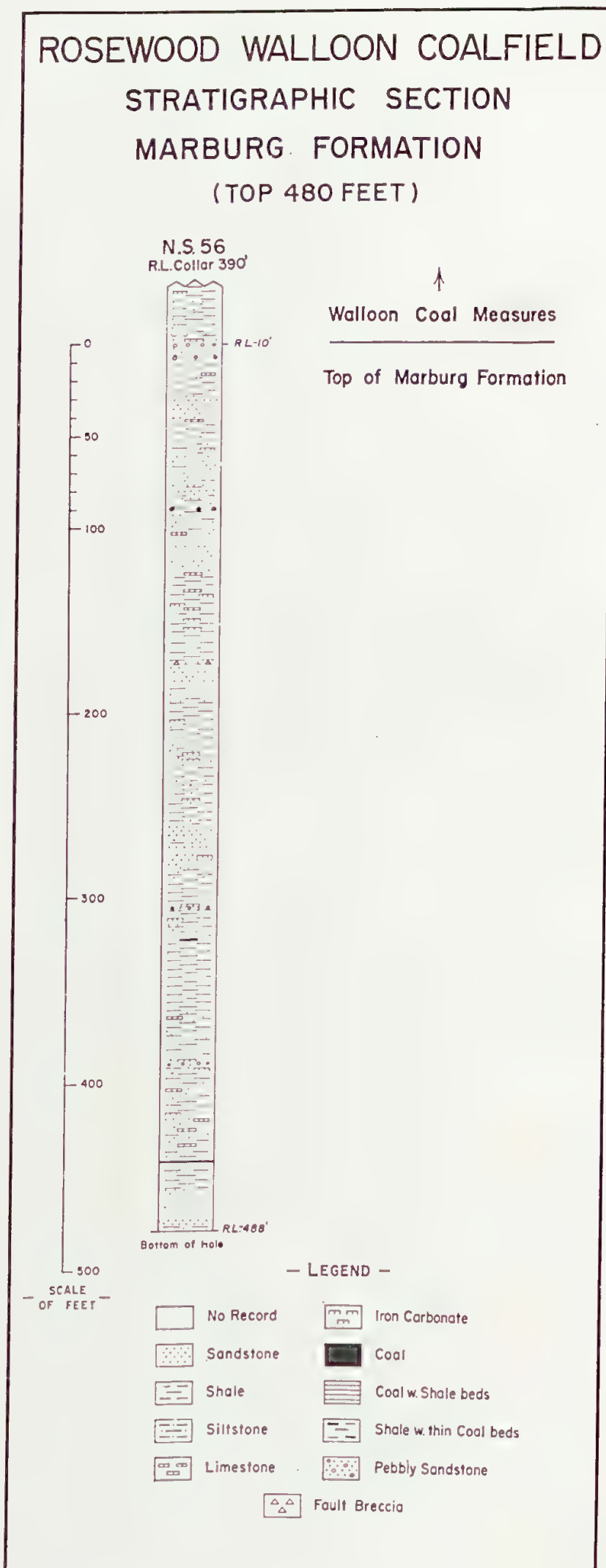
#### LITHOLOGY

During the course of the diamond drilling programme eleven holes were drilled to the Marburg Formation, the depth of penetration in that unit varying, with one exception, from 6 to 83 feet; in drillhole N.S. 56 in the United No. 8 mine area, 478 feet of the formation were cored. The stratigraphic sections thus recorded show that although there are no significant occurrences of coal, many of the lithologic types so characteristic of the Walloon Coal Measures—fine-grained sandstone, both argillaceous and calcareous; and shale and siltstone with thin lenticular beds of iron and calcium carbonate—are quite common in the upper part of the Marburg Formation. In particular, shale and siltstone beds are by no means minor components; in drillhole N.S. 56 they constitute approximately half the section (fig. 2). The outstanding difference between the two formations lies in the maximum grain size of the sediments; certain beds of the Marburg Formation possessing, as Reid (1921) first pointed out, "a gritty character not seen in the Rosewood beds". The uppermost of these "gritty" beds, which comprise fine to coarse sandstone with pebbly layers and pebble conglomerate, is taken as the top of the formation. The coarse-grained sediments in the upper part of the Marburg Formation rarely form beds more than a few feet thick, but being more quartzose than the other sandstones they outcrop well in comparison. Hence their presence is a reliable criterion for mapping the upper limit of the formation, even in those areas where they constitute only a minor part of the section.

#### DISTRIBUTION

In the Rosewood-Walloon Coalfield the accurate delineation of the top of the Marburg Formation is of considerable importance; because of the paucity of outcrops in the Walloon Coal Measures, it is only by mapping the top of the underlying formation that the

FIG. 2





occurrence of the coal-bearing beds can be established in those areas not yet exploited. By using the boundary criteria previously mentioned, the junction of the Marburg Formation and the Walloon Coal Measures has been mapped from Marburg to Franklin Vale Creek in the west and Hampstead in the east. This mapping differs considerably from that of Hill and Tweedale (1955) and also Swindon (1960), who considered that the top of the Marburg Sandstone could be "traced from Glamorganvale to Hatton Vale". Both to the west and east of Marburg, however, much of the strata mapped by Swindon as the lower part of the Walloon Coal Measures is now known to represent the upper beds of the Marburg Formation; these strata include thin beds of coarse pebbly sandstone and pebble conglomerate, lithologies which do not occur in the Walloon Coal Measures (Reid, 1921).

In the western part of the coalfield, the recognition of such coarse-grained sediments as part of the Marburg Formation is by no means a new concept. Although Reid (1922b) mapped the area to the west of Lanefield as Walloon "Series" in the sense of his (1922a) definition, he later (1927) described the country thereabouts as "largely made up of clay shales" with "numerous thin beds of hard sandstones and grits". Reid called this sequence the "Lower Sandstone Series" and correlated it with the Marburg "sandstone stage". Likewise, the Bureau of Investigation (1949, fig. 5), Cameron (1961b), and McTaggart (1963a) recognized the unproductive beds to the west of Lanefield as part of the Marburg Formation. In the eastern part of the coalfield, the strata now mapped as Marburg Formation were recognized as such far more recently (Cameron, 1963d; McTaggart, 1963a; Jorgenson and Barton, 1966).

In the Loamside area, these beds of the Marburg Formation, dipping more steeply than usual as a result of their involvement in the West Ipswich "fault" (Denmead, 1955, p. 17), overlie with apparent conformity the upper members of Cameron's Bundamba Beds. However, it has not been possible to establish the exact stratigraphic relationship between this underlying rock unit and the lower beds of the Marburg Formation in the type area for, during the investigation of the Rosewood-Walloon Coalfield, examination of the Bundamba Beds has been only incidental and, furthermore, mapping of Marburg strata elsewhere in the coalfield has been restricted to the top few hundred feet of the formation. Consequently, strata mapped by Cameron (1907, 1923) as Bundamba Beds are referred to as such in this report.

#### PALAEONTOLOGY

Macrofossils are not common in the Marburg Formation in the type area, being represented mainly by plant impressions. The recorded flora is restricted to the three species, *Cladophlebis australis* (?) and *Taeniopteris spatulata* (?) (Reid 1922b, p. 466), and *Equisetum laterale* (Gould 1968a), the lastmentioned being previously identified as *Equisetites rotiferum* (Hill, Playford, and Woods, 1966). The fauna comprises the freshwater lamellibranchs *Unio* and

*Unionella* (?) (Reid 1922b) and a jaw fragment of a labyrinthodont *Austropelor wadleyi* (Longman, 1941; and Colbert, 1967).

Because of the similarity of its flora to that of the overlying Walloon Coal Measures which Walkom (1918 and 1919) considered to be Lower Jurassic, Reid (1922a) assigned a "(Lower?)" Jurassic age to the Marburg Formation. Whitehouse (1955), however, considered that the occurrence of *Austropelor wadleyi* indicated that the formation was Upper Triassic as "labyrinthodonts are not known anywhere else in the world later than Triassic". Hill and Tweedale (1955) realized that the labyrinthodont fragment had come from near the base of the formation and so treated the Marburg Formation as Triassic to Jurassic in age.

More recently the Marburg microflora has been described by de Jersey (1963), 33 species of spores and pollen being recorded. As a result of this study, de Jersey has suggested that the whole of the Marburg Formation should be placed in the Jurassic. This suggestion is based on the occurrence throughout the sequence of several forms which are known from Jurassic sediments elsewhere, but have not been found in the Triassic. One of these, *Classopollis*, has been recorded from interbedded sandstone and shale near the base of the formation at Lowood, close to the spot where the jaw fragment of *Austropelor wadleyi* was collected. In this conflict in the palaeontological evidence, de Jersey has advocated that greater reliance should be placed on the microflora than on an isolated bone fragment and has also drawn attention to the possibility "that the jaw fragment in question, if correctly identified, may be a reworked fossil from underlying Triassic sediments". With this solution of the problem Colbert (1967) is in agreement.

Besides indicating a positive Jurassic age, the Marburg microflora allows more definite positioning of the formation within that period. From a comparison with other Jurassic microfloras in Western Australia, where the presence of intercalated marine sediments has enabled the microfloral assemblages to be dated accurately by means of marine faunas, de Jersey (1963) has suggested "a Liassic age (possibly extending into the Bajocian)" for the Marburg Formation.

#### WALLOON COAL MEASURES

In contrast to the Marburg Formation, the Walloon Coal Measures weather to a mature topographic surface with clay soils and relatively few outcrops, so that surface mapping of coal seams or other beds within the formation is not possible as a general rule. The work of Reid (1921, 1922a, 1927) was based largely on information gained from underground mining operations and even these at the time were very limited. However, the extensive core drilling programme of recent years, together with the expansion of coal mining operations, has greatly increased knowledge of the subsurface geology of the coalfield and has shown that the coal seams, while workable only



over limited areas, are far more persistent than previously believed and that the concept of lenticularity as applied to the coal beds by Reid (1921, fig. 2; 1922a, fig. 5) is no longer tenable. The detrital sediments of the formation, however, are extremely lenticular and, in most cases, it is thickening of the shale beds within the seam which renders it unworkable and not lensing of the seam itself. By the application of normal stratigraphic methods, coal seam correlation has been effected over an area of some 30 square miles embracing all the present working collieries of the coalfield. A total of eighteen coal seams has been recognized and named and, for the first time, an accurate stratigraphic column of the Walloon Coal Measures in the type area has been compiled.

#### LITHOLOGY

As encountered in the subsurface, the Walloon Coal Measures consist mainly of light grey shale and mudstone, siltstone, fine-grained sandstone, and thin coal seams (Cameron, 1960a). The coarse sandstone, pebbly sandstone, and pebbly conglomerate, so characteristic of the Marburg Formation, are absent.

The dominant arenaceous rock type is a grey-white, poorly consolidated, massive sandstone with numerous dark lithic grains and an abundant silt and montmorillonite clay matrix. Such sandstones occur as lenticular bodies in places up to 50 feet thick, commonly with a disconformable base and incorporating shale and coal fragments, the products of penecontemporaneous erosion. The relief of the erosion surface is usually no more than a few feet, but, where the sandstones are developed immediately above coal seams, washouts of economic significance may result. Although they constitute an important lithological type in the subsurface, these argillaceous sandstones, because of their high susceptibility to weathering processes, are rarely seen in outcrop. Surface exposures of sandstone are usually restricted to thin beds, up to 2 feet thick, of calcareous sandstone, which, however, constitute only a small percentage of the formation. A third arenaceous rock type is a sandstone which contains only a minor proportion of clay matrix and occurs interbedded with siltstone, shale, and mudstone. A characteristic feature of all sandstones in the Walloon Coal Measures, as developed in the Rosewood-Walloon Coalfield, is their average grain size, the median diameter in all cases being less than 0.5 mm. Coarse sandstones, in terms of Wentworth's (1922) grade scale, do not occur. In fact, the majority of the sandstones, including all those in the coal-bearing section, are fine-grained with a median diameter of less than 0.25 mm; medium-grained sandstones occur only in the upper unproductive part of the formation.

In contrast to the montmorillonite of the clay fraction of the sandstones, kaolinite is the dominant clay mineral of the light grey shales and mudstones of the Walloon Coal Measures. Whereas the shales usually occur thinly interbedded with siltstones and sandstones, the mudstones form much thicker,

massive beds with little or no sign of lamination. Commonly associated with these argillaceous rocks are lenticular masses of clay ironstone (iron carbonate) ranging up to 12 inches in thickness. On the surface these are represented by red and brown iron oxides in the form of beds and boulders which may show concentric weathering effects. Thin concordant veins of calcium carbonate with a maximum thickness of several inches also occur; these are of secondary origin and usually exhibit cone-in-cone structure.

Within the Walloon Coal Measures individual coal beds are rarely more than 2 feet thick and so workable seams generally comprise two or more such coal units separated by beds of grey shale, siltstone, and sandstone of varying thickness. Besides these lenticular stone interbeds, another quite distinct lithologic type occurs in association with many of the coal seams. This is a waxy shale, light grey to fawn in colour, which is composed mainly of montmorillonite with minor amounts of kaolinite and quartz. These montmorillonite clays occur interbedded with the coal as thin beds usually no more than 6 inches thick, although several beds with a thickness of approximately 2 feet are known. Because of their uniform thickness, lateral persistence and characteristic lithology, they serve as very useful marker beds for coal seam correlation.

The coal seams consist mainly of bright coal which is poorly banded and moderately cleated, the cleats in places being filled with thin deposits of calcium and iron carbonate minerals. Thin lenticular beds of cannel-like coal also occur. Within the coal on certain horizons iron carbonate is concentrated in the form of thin, discontinuous lenses of "boulder". As a result of an increase in sedimentary mineral matter, some coal plies grade laterally into inferior coal or "bluey", which is characterized by a more widely spaced cleat and then into carbonaceous shale. Low grade oil shale also occurs: this is brownish in colour, extremely fine-grained, and very fissile.

#### STRATIGRAPHIC COLUMN

Although Reid (1922a) considered that the junction between the Marburg and Rosewood "stages" was disconformable, recent investigations have shown that the contact between the Marburg Formation and the Walloon Coal Measures is gradational and conformable and that there is no evidence of divergence between the strike of the beds and the boundary of the two formations. The junction between the two rock units is taken as the top of the uppermost bed of coarse pebbly sandstone or pebble conglomerate.

At the base of the Walloon Coal Measures there are 60 to 90 feet of strata with gross lithology similar to that of the overlying beds, but without coal seams. This lower unproductive section has many lithological aspects in common with the upper beds of the Marburg Formation, but is differentiated from that unit by the complete absence of coarse-grained sediments.

Overlying these barren strata are approximately 500 feet of coal-bearing beds, the seams being more or less evenly distributed throughout a sequence of



light grey shales, siltstones and fine-grained sandstones with thin beds of iron and calcium carbonate. There are eighteen persistent seams which have been named for the first time on a coalfield-wide basis. In ascending stratigraphic order these are the Rea, Bruce, Haenke, Wass, Kathage, Stewart, Cowell, Butler, Boughen, Joynson, Roots, Little Jim, Trewick, Gunthorpe, John, Hardie, Hall, and Hudson seams. Besides these major seams, there are other less persistent seams which exhibit much lateral variation and seldom approach workable thickness or quality. As far as is known, none of these thin coal beds has yet been exploited; in consequence, they have not been examined very closely, although locally some of these seams serve as useful aids in stratigraphic correlation. On the other hand, the named seams, all but one of which (the Hudson seam) have been worked, have been studied in considerable detail. Their behaviour throughout the coalfield is fully described in a later section of this report.

The coal-bearing beds of the Walloon Coal Measures are overlain by at least 150 feet of massive sandstone with minor shale intercalations and, in several localities, one thin unworkable coal seam. The sandstones are mainly argillaceous, but some beds are cemented with calcium carbonate and, less commonly, iron carbonate. They are similar mineralogically to the sandstones in the other parts of the formation, but are distinguished by the greater average grain size of certain beds; medium-grained sandstones occurring along with the usual fine-grained varieties. A characteristic feature of this upper sandstone unit is its disconformable base; the maximum erosional relief observed at its contact with the coal-bearing beds is approximately 20 feet. This relationship is undoubtedly the result of penecontemporaneous erosion, for the sandstone commonly contains shale and coal fragments derived from the underlying strata. Furthermore, certain thin beds of shale arenite associated with the sandstone are composed almost entirely of shale fragments of sand size set in a montmorillonite clay matrix. The total thickness of this upper sandstone unit is not known, since, in the area examined, its upper surface is one of erosion, in places being buried by several hundred feet of Tertiary basalt and sediments.

Thus in the Rosewood-Walloon Coalfield, the Walloon Coal Measures have a maximum proved thickness of approximately 750 feet and are divisible in the subsurface into three lithologically distinct portions:—

- (1) An upper fine- and medium-grained sandstone unit at least 150 feet thick.
- (2) The coal-bearing beds approximately 500 feet thick.
- (3) A lower section of fine-grained sandstones and shales, 60 to 90 feet in thickness, without coal seams.

On the surface, however, because of the paucity of outcrops, the lower two portions cannot be differentiated and the upper sandstone does not constitute a readily mappable unit although it can be distinguished by much detailed work. Consequently, no

formal names have been applied to these three divisions. To the south of the area mapped, however, the upper sandstone is more completely developed and further work there may show that this unit is deserving of formal member status.

The stratigraphic column for the Walloon Coal Measures presented in this report has been compiled from numerous subsurface sections measured throughout the Rosewood-Walloon Coalfield and so is based on as full a knowledge as possible of the formation's lateral and vertical variations (see fig. 3). However, to ensure nomenclatural stability it is essential that a type section be designated.

One might expect, as did Whitehouse (1955, p. 8), that the type locality for the formation would be about the township of Walloon, but it must be remembered that when Cameron first applied that geographic name to the coal-bearing beds to the west of Ipswich, he did so because the "beds were first worked for coal at Walloon" (Cameron, 1905, p. 459) and not because they were typically developed thereabouts. It is now known that around the township of Walloon only the lower few hundred feet of the Walloon Coal Measures outcrop; the formation is more completely developed several miles further to the west in the vicinity of Rosewood, but still within the boundaries of the Parish of Walloon, County of Churchill.

A representative section of the Walloon Coal Measures extends from approximately 1 mile south of Marburg through Rosewood to Ebenezer and beyond, the absence of a definite upper limit arising from the fact that within the area examined the top of the formation is not developed. Choice of this section as the type section, however, would not be appropriate as the lack of good exposures and the presence of blanketing Tertiary and Quaternary deposits precludes the accurate measurement and detailed description of the stratigraphic sequence by surface observations. Fortunately, the section has been cored continuously in the subsurface between the depths of 24 feet 6 inches and 772 feet in diamond drillhole N.S. 84 situated in the Ebenezer district. This section is designated as the type section of the Walloon Coal Measures. It should be noted, however, that for reasons previously discussed, the upper limit of the section specified does not represent the top of the formation.

Diamond drillhole N.S. 84, drilled by the Department of Mines as part of its programme of coal exploration in the Smithfield No. 3 mine area, is situated at a point, bearing 340° true, 27 chains from the south-east corner of Sub. 1 of Portion 39, Parish of Jeebropilly, County of Churchill, and approximately 2 miles south-south-east of the town of Rosewood. Core from the type section of the Walloon Coal Measures, totalling 712 feet and representing almost 750 feet of strata, was logged in detail by geologists of the Geological Survey and is now deposited at the Department of Mines Core Library at Redbank. A log of the type section in graphic form is submitted herewith (fig. 4).



FIG. 4

## DISTRIBUTION

Except where covered by Cainozoic deposits, the Walloon Coal Measures occupy the roughly semi-circular area extending from Franklin Vale Creek in the west to Marburg in the north and Hampstead in the east. This distribution is controlled by geological structure, the area mapped being situated at the northern extremity of a shallow syncline developed in the Walloon Coal Measures and the underlying Marburg Formation.

Although three lithologically distinct units can be recognized in the Walloon Coal Measures in the subsurface, this differentiation is generally not possible by surface observations. On the geological map accompanying this report (fig. 25), the position of the coal-bearing beds has been determined, in the absence of subsurface data, by mapping the underlying Marburg Formation and, where possible, the overlying unproductive sandstone unit.

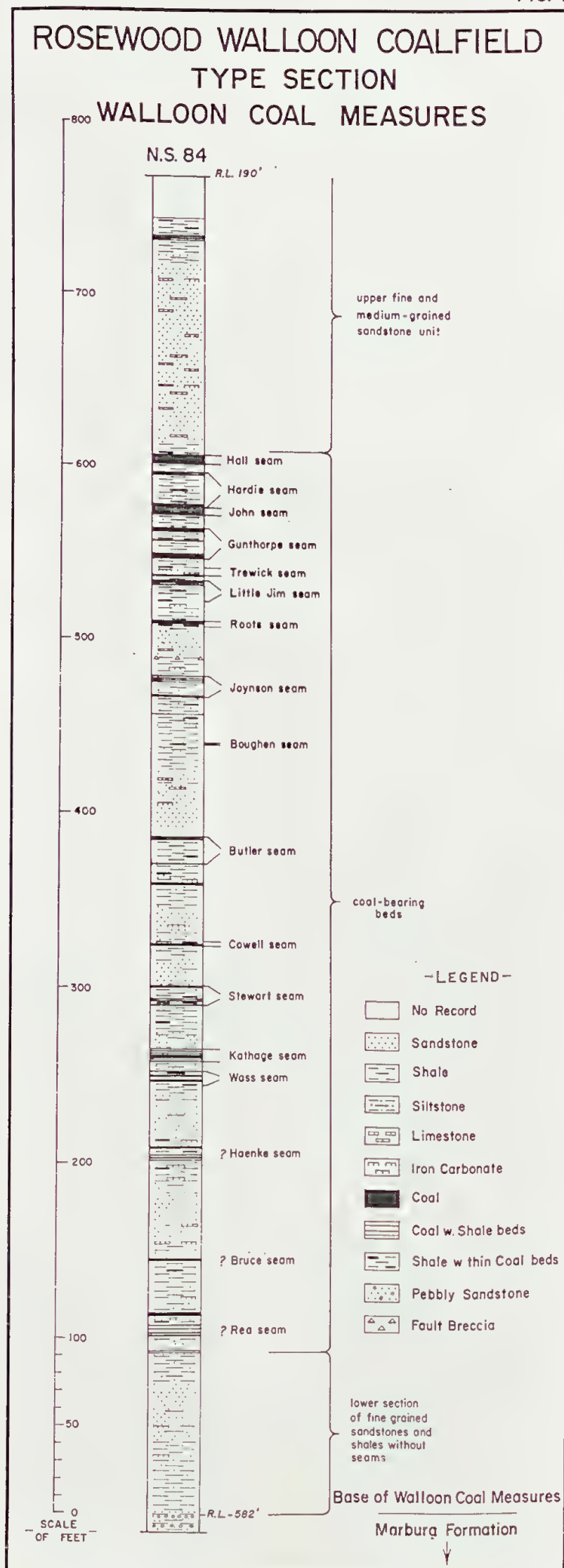
## PALAEOLOGY

Although dinosaur footprints have been recorded from several collieries in the Rosewood-Walloon Coalfield, the dominant macrofossils in the Walloon Coal Measures are plant impressions. On the surface, these are found mainly in the more resistant red, ferruginous sandstones and clay ironstones as noted by Reid (1922a, p. 18); in the subsurface, however, they occur also in the grey shales, particularly the roof shales of coal seams. Fossil wood, as ferruginous replacements, is fairly common throughout the formation.

Fossil plants from the Walloon Coal Measures of the Rosewood-Walloon Coalfield were first described by Tenison-Woods (1884) and later by Etheridge Jnr. (Jack and Etheridge, 1892) and Walkom (1915, 1917a, b). The latter recorded some 37 species from the Walloon "Series", this term then being used in the sense of Dunstan (1913, pl. 7); all but four of these species were collected from outside the coalfield, 20 species, in fact, coming from beds which were subsequently shown to belong to the Esk "Series" (Reid and Morton, 1923). Since Walkom's work, additional forms have been recorded by Reid (1922a), de Jersey (1959, 1960a-b), Hill, Playford, and Woods (1966), and Gould (1968a). The following is a list of fossil plants recorded to date from the Walloon Coal Measures of the type area; doubtful determinations have been omitted.

*Brachyphyllum crassum*  
*Cladophlebis australis*  
*Coniopteris cf. delicatula*  
*Coniopteris sp.*  
*Equisetum bryanii*  
*Equisetum laterale*  
*Phyllopteris feistmanteli*  
*Sphenopteris sp.*  
*Taeniopteris spatulata*

Among this limited flora, "*Cladophlebis australis* and, to a less degree, *Taeniopteris spatulata* are the predominant species" (Reid, 1923). A study of the flora of the Walloon Coal Measures is presently being undertaken by Gould (1968b, p. 509).





From a comparison with floras in other parts of the world, Walkom (1918, 1919) concluded that the flora of the Walloon "Series" was of Lower Jurassic age. As previously mentioned, however, Walkom's Walloon flora included many species from the Esk "Series"; this Esk flora he subsequently suggested was Rhaetic or possible Upper Triassic (Walkom, 1924, 1928). One might expect, therefore, that the more restricted flora of the Walloon Coal Measures would indicate an age somewhat younger than Lower Jurassic. This thought may have led Reid (1922a) to assign an "(upper?)" Jurassic age to the Walloon Coal Measures.

More recently the microflora of the Walloon Coal Measures from the Rosewood-Walloon Coalfield has been described by de Jersey (1959, 1960a), 40 species of spores and pollen grains being recorded. From a comparison with other Jurassic microfloras, particularly those in Western Australia where the presence of interbedded marine sediments has enabled the microfloral assemblages to be dated accurately by means of marine faunas, de Jersey suggested a Lower Jurassic age for the Walloon Coal Measures. However, after a re-interpretation of the microfloral evidence, on the basis of the first appearance of selected species, de Jersey and Paten (1964) favoured a Middle Jurassic age for the unit.

Dinosaur footprints in the Walloon Coal Measures of the Rosewood-Walloon Coalfield were first described by Ball (1933, 1934a, b) from the roof of the Bruce seam in Lanefield No. 2 Colliery. Similar tracks were later recorded from the same horizon in the nearby Lanefield Extended No. 2 Colliery (Ball, 1946). The Geological Survey of Queensland (1952) again reported dinosaur footprints in the Rosewood district, on this occasion from Lowfield No. 2 Colliery. These impressions were, in fact, encountered in the workings of the adjacent Westvale No. 6 Colliery and were preserved within the Wass seam. A further occurrence was recorded from Westvale No. 5 Colliery by Hill, Playford, and Woods (1966).

During the course of the Department of Mines programme of coal exploration in the Rosewood-Walloon Coalfield, there have been reports of further exposures of dinosaur tracks, but only one of these was examined. In this occurrence in the roof of the Wass seam in Caledonian No. 5 Colliery the footprints were very similar in shape and size to those previously described, being those of a three-toed bipedal dinosaur and measuring 18 inches from the tip of the median toe to the heel and 20 inches between the extremities of the two lateral toes; the toes themselves were 10 to 11 inches in length and 3 to 4 inches wide. The width of the imprint at the base of the toes was 14 inches.

Unfortunately the dinosaur footprints occurring in the Walloon Coal Measures are of little help in determining the age of the formation. Within the Rosewood-Walloon Coalfield, more tangible evidence in the form of dinosaur bones has yet to be discovered.

## CAINOZOIC

The Mesozoic rocks of the Rosewood-Walloon Coalfield are overlain in many places by Cainozoic deposits. Two lithologically and genetically distinct units can be recognized—Tertiary Volcanics and Sediments, and Quaternary Alluvium.

### TERTIARY VOLCANICS AND SEDIMENTS

Tertiary rocks are distributed throughout the coalfield as a series of small outliers comprising in most cases both basalt and sediments. These strata are practically horizontal and lie unconformably on the Mesozoic rocks. Although in local areas there is evidence of the uneven topography of the land surface on which they were deposited, there is a gradual rise in the altitude of the base of the Tertiary beds across the coalfield from east to west—from sea level in the Amberley district (diamond drillhole N.S.1) to approximately 750 feet on the Bluff. Reid (1922b) showed that this trend continues to the west as far as the Main Range and later (1926) commented on its significance.

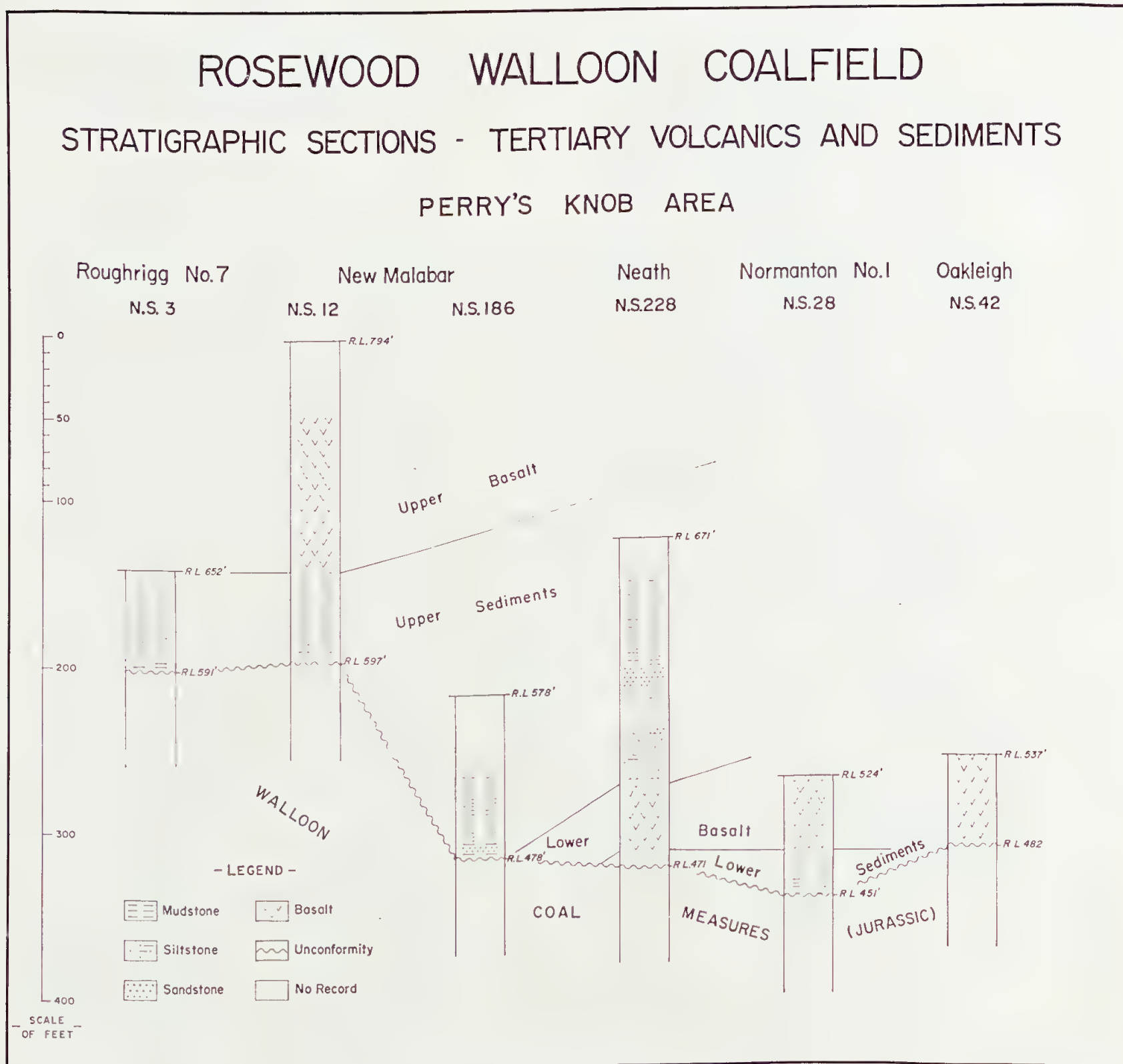
### STRATIGRAPHIC COLUMN

During the investigation of the Rosewood-Walloon Coalfield, the Tertiary outlier in the Perry's Knob area was the only one examined in any detail, particularly in the subsurface. There, a section of some 550 feet of basalt and sediments is developed (fig. 5). Over the greater part of the area, the basalt occurs as two distinct units separated by up to 200 feet of mudstone and sandstone with sporadic layers of siliceous pebbles and boulders. Both towards Mount Marrow in the north-east and the Normanton No. 1 mine area in the south-west, however, these Tertiary sediments appear, from surface mapping, to lens out abruptly. In certain localities, further Tertiary sediments occur beneath the lower basalt, but these, on present knowledge, are never more than 25 feet thick. Thus the Tertiary sequence in the Perry's Knob area comprises lower sediments, lower basalt, upper sediments, and upper basalt. However, due to the marked relief of the land surface on which they were deposited, all four units are not necessarily developed everywhere in the outlier; for instance, in those localities which were the sites of pre-Tertiary topographic highs, the upper sediments rest directly on the Mesozoic rocks.

### LITHOLOGY

The Tertiary sediments of the Perry's Knob area are mainly grey mudstones and shales, although in places the mudstones are variously coloured brown, red, and purple. Interbeds of poorly consolidated quartzose sandstone up to 20 feet thick also occur; these generally contain thin lenticular beds of more resistant ferruginous sandstone. The arenaceous rocks are mainly fine-grained with an abundant clay matrix, but small bodies of coarse pebbly sandstone are fairly common. A characteristic feature of the Tertiary sandstones is the occurrence of layers of rounded





pebbles and boulders composed chiefly of white and grey quartzite with some jasper and black chert. As a general rule, the Tertiary sediments outcrop poorly and, quite often, it is only by the presence of these siliceous pebbles and boulders strewn over the surface that the existence of underlying Tertiary beds can be established. Surface mapping is further hampered by the occurrence of basalt boulders, some of considerable size, lying directly on Tertiary sediments. These are relics of the overlying basalt long since removed by denudation and are preserved in their present position because of their greater resistance to weathering processes.

In some localities Tertiary sandstones have been thermally metamorphosed by overlying basalt. The resultant quartzite beds are generally only a few feet thick, but they are extremely hard and so outcrop strongly. The most prominent occurrence is in Portion 563, Parish of Walloon, on the eastern slopes of the Bluff. This particular outcrop was mentioned by Reid (1922a, p. 16), who believed that the original sandstone was part of the Walloon Coal Measures. However, because of its quartzose nature and the presence of coarse grains and pebbles, there is no doubt that the quartzite was derived from sandstone of Tertiary age.



The Tertiary volcanic rocks of the Perry's Knob area are predominantly basalts, in places vesicular and amygdaloidal; thin beds of tuff have been recorded in several localities. In the upper basalt, particularly towards the base, there occur interbedded magnesian limestones which in places have been replaced in varying degrees by chalcedonic silica. Thin beds of black shale also occur between some of the lava flows constituting the upper basalt (Reid, 1922a, p. 52).

In addition to the effusive rocks, Tertiary igneous activity in the Rosewood-Walloon Coalfield is represented by basaltic dykes and sills which intrude the Walloon Coal Measures. Prior to the commencement of the Department of Mines programme of exploratory diamond drilling, the existence of such intrusive rocks was unsuspected, but Cameron (1963f) recorded the occurrence of a basaltic sill intruding a coal seam in the New Amberfield mine area. Later, Chiu Chong (1963c) drew attention to the numerous dykes and sills encountered both in diamond drill holes and colliery workings in the Caledonian No. 5 mine area. These latter intrusions appear to have emanated from the nearby Mount Marrow, which suggests that this feature may represent a volcanic plug. A similar view, based on geomorphological considerations, was put forward by Reid (1922b, p. 468).

The basalts and associated sediments of the Rosewood-Walloon Coalfield are very similar lithologically to the Tertiary beds of the Ipswich Coalfield, the sequence in both areas being characterized by soft sandstones, variously coloured mudstones, and basalts with interbedded magnesian limestone. The Tertiary rocks around Ipswich constitute the Booval Group (Staines, 1960a, b) and there is little doubt that the basalts and sediments of similar age which occur further west in the Rosewood-Walloon Coalfield are correlatives of that rock unit.

#### DISTRIBUTION

The Tertiary rocks outside the Perry's Knob outlier have not been investigated in detail, but their distribution has been mapped as accurately as surface observations will allow. This work has shown that both basalts and sediments are fairly widespread throughout the coalfield particularly in the eastern part.

For many years, much uncertainty has existed as to the occurrence of Tertiary sediments in the area to the west of Ipswich. Cameron (1913) reported the finding of Tertiary beds around Karrabin and later (1923), on his Ipswich Coalfield Map No. 1, he showed a large area further south as belonging to the same system. However Reid and Morton (1922, p. 391), commenting on Cameron's (1923) work which was then in press, saw "no evidence of Tertiary strata except soft fissile shales, associated with basalt near Loamside" and so they deleted all of Cameron's occurrences of Tertiary sediments to the west-north-west of Ipswich, considering them to be Mesozoic. Jones (1926, p. 43) also disagreed with Cameron; he concluded that there were no occurrences of Tertiary sediments to the south-west of Ipswich, but rather, that "this area proved to belong to the Walloon Series". The existence of Tertiary sediments to the west of

Ipswich was again advocated by Denmead (1955) who mapped rocks of this age in the Loamside and Wulkuraka areas. Denmead did consider it probable, however, that some of Cameron's Tertiary areas may be "outliers and/or marginal areas of Walloon beds".

During the present investigation of the Rosewood-Walloon Coalfield, Tertiary sediments were mapped in the eastern part in the Loamside, Karrabin, and Amberley districts; in all of these localities Tertiary basalts also occur. It is now evident that in the area to the west of Ipswich, Cameron mapped as Tertiary sediments far too large an area, but that the action of Reid and Morton and also Jones in removing all these occurrences to the Mesozoic was likewise too extreme. The true position regarding the distribution of Tertiary sediments in the eastern part of the coalfield would appear, therefore, to lie somewhere between these two diverse views. However, due to the paucity of outcrops in areas underlain by Mesozoic and Tertiary sediments, accurate delineation of the boundaries between these rock units is not always possible. Consequently, the distribution of Tertiary sediments shown on the geological map accompanying this report must be considered approximate and it is likely that more detailed mapping will result in the extension of the existing areas and the finding of new occurrences, now unsuspected.

From an economic point of view, the distribution of Tertiary beds is of some significance. In certain areas now occupied by Tertiary strata, considerable quantities of coal have been lost as a result of pre-Tertiary denudation. Such is the case in the New Amberfield mine area in the Amberley district (Cameron, 1963f) but, fortunately, this is not common. In other areas, however, the Tertiary basalts form a protective capping to the softer coal-bearing beds. This is so on the high country to the north of Rosewood, particularly around Perry's Knob, where large tonnages of coal have been preserved from erosion by this means.

#### PALAEONTOLOGY

Although Gregory (1879) considered the basalts of the West Moreton district to be Tertiary, some later workers such as Jack and Etheridge (1892) believed that they occurred within the Mesozoic sequence. Since the work of Richards (1916), however, a Tertiary age for these volcanic rocks has been accepted. Richards' conclusions were based, in part, on palaeontological evidence in the form of dicotyledonous plant remains from several places, one locality mentioned being "near Rosewood" (p. 123). In every case, the fossils were preserved in beds of diatomaceous earth a few feet thick which occurred between massive basalt flows. It is interesting to note that some 30 years previously, Tenison-Woods (1882) mentioned plant beds in the Rosewood Scrub, apparently unconnected with any coal formation, and which he considered to be of Tertiary age. Since the work of Richards, Reid (1922a, p. 20) reported the finding of further dicotyledonous plant impressions; these occurred in black shales interbedded with basalts on "One-tree Hill west of Kunkala Station".



### QUATERNARY ALLUVIUM

Large areas of the coalfield are blanketed by alluvial deposits of Quaternary age.

To the south of the Southern and Western Railway, the alluvium is confined to the flood plain of the Bremer River and its major tributaries, Franklin Vale, Western, Warrill and Purga Creeks. Although black clay is the dominant lithologic type on the surface, lenticular beds of water-bearing sand and gravel also occur at depth. The maximum thickness of alluvium in this area is not known, but percussion drilling for coal has shown that in Portion 9, Parish of Walloon, just north of the Bremer River, it is at least 60 feet thick.

The alluvium in the northern part of the coalfield is quite distinct from the flood plain deposits of the Bremer River to the south, occurring at a higher elevation along the small creeks and gullies which have their source in the high country extending from the

Bluff to Mount Marrow. Where these watercourses emerge from the more precipitous terrain onto the lowlands south of the divide, considerable aggradation has taken place. The material so deposited consists mainly of black clay with layers of basaltic sand and gravel and commonly occurs as small alluvial fans. In places, these fans coalesce to form alluvial deposits of considerable extent; this is so particularly to the north of Lanefield and Thagoona. Ball (1946) recorded nearly 90 feet of such alluvium at Lanefield Extended No. 2 Colliery and considered that it was of Pleistocene age.

Although in certain parts of the coalfield these flood plains and piedmont-type alluvial deposits constitute two distinct physiographic features, at their margins they grade, more or less imperceptibly, one into the other. In consequence, no attempt has been made to differentiate between them on the geological map (fig. 25).

### COAL SEAMS

Stratigraphic studies in the Rosewood-Walloon Coalfield in the years 1962 to 1964 have shown that within the coal-bearing beds of the Walloon Coal Measures there are eighteen persistent coal seams, all but one of which have been worked. In the past, due to the lack of established seam correlation from one mine area to another, each of these seams has been referred to by a variety of local names, based usually on the registered name of the colliery in which it was exploited, for example, Lanefield No. 5 seam, Oakleigh Airshaft seam, United No. 8 Top seam. Although adopted for all the coal resources reports published in the years 1954 to 1963, this method of naming coal seams can lead to considerable confusion, employing, as it does, numbering to distinguish both coal seams and mine openings. For instance, the name Normanton No. 2 seam has been applied to the second worked seam in the succession at Normanton No. 1 Colliery; it could equally as well refer to the quite different seam worked in Normanton No. 2 Colliery. Consequently, now that it is possible to name the coal seams in the Walloon Coal Measures on a regional basis, it is considered advisable that, instead of selecting existing names according to the rules of priority, a completely new system of coal seam nomenclature be introduced. In this report, therefore, each of the eighteen persistent

seams has been named, as far as circumstances allow, after the identity in the local coal mining industry who was responsible for its earliest exploitation.

The named seams in descending stratigraphic order are as follows:—

|           |            |         |
|-----------|------------|---------|
| Hudson    | Little Jim | Stewart |
| Hall      | Roots      | Kathage |
| Hardie    | Joynson    | Wass    |
| John      | Boughen    | Haenke  |
| Gunthorpe | Butler     | Bruce   |
| Trewick   | Cowell     | Rea     |

Besides these named coal seams there are other less persistent seams which exhibit much lateral variation and seldom approach workable thickness or quality. Mention will be made of these coal beds only where they serve as useful local aids in stratigraphic correlation.

Table III shows the relationship between the names now proposed for coal seams and those previously used by the local coal mining industry and in prior reports by officers of the Geological Survey of Queensland.

The eighteen named seams have been studied in considerable detail and their behaviour throughout most of the coalfield is well known.



| Mine Area<br>Seam | Roughrigg No. 7  | New Malabar No. 1                                    | Lanefield No. 5                   | Normanton No. 1        | Neath Nos. 1 & 2                   | Glencoe Extd. & Glencoe Extd. No.1 | Westvale No. 5  | Oakleigh Nos. 3 & 4              | United No. 8        | Smithfield No. 3 | Rosemount No. 4           | New Mountain View No. 3  | United No. 7        | Roughrigg No. 5         | Westvale No. 7             | Mount Elliott No. 1 Extd.        | Moorefield No. 4       | New Amberfield | Rosewood No. 2                   | Caledonian Nos. 5 & 6   | Mine Area<br>Seam          |
|-------------------|------------------|------------------------------------------------------|-----------------------------------|------------------------|------------------------------------|------------------------------------|-----------------|----------------------------------|---------------------|------------------|---------------------------|--------------------------|---------------------|-------------------------|----------------------------|----------------------------------|------------------------|----------------|----------------------------------|-------------------------|----------------------------|
| Hudson            |                  |                                                      |                                   |                        |                                    |                                    |                 |                                  |                     |                  |                           |                          |                     |                         |                            |                                  |                        |                |                                  |                         | Hudson                     |
| Hall              | Roughrigg Top    |                                                      |                                   | Normanton No. 1        | Neath Top                          | Glencoe No. 1 or Little Glencoe    |                 | Oakleigh No. 1                   |                     | Top              |                           |                          |                     | Roughrigg Top           |                            |                                  |                        |                |                                  |                         | Hall                       |
| Hardie            |                  |                                                      |                                   | Normanton No. 2        |                                    | Normanton No. 2                    |                 | Normanton No. 2                  |                     | Bottom           |                           |                          |                     |                         |                            |                                  |                        |                |                                  |                         | Hardie                     |
| John              |                  |                                                      |                                   | Glencoe No. 2          |                                    | Glencoe No. 2                      |                 | Oakleigh No. 2.                  |                     |                  |                           |                          |                     |                         |                            |                                  |                        |                |                                  |                         |                            |
| Gunthorpe         | Roughrigg Bottom |                                                      |                                   | Normanton No. 3        | Neath Bottom                       | Glencoe No. 3                      |                 | Oakleigh No. 3                   |                     | Lower            |                           |                          |                     | Roughrigg Bottom        |                            |                                  |                        |                |                                  |                         | Gunthorpe                  |
| Trewick           |                  |                                                      |                                   | Normanton No. 4 (tops) |                                    | Glencoe No. 4                      |                 | Oakleigh No. 4                   |                     |                  |                           |                          |                     |                         |                            |                                  |                        |                |                                  |                         | Trewick                    |
| Little Jim        |                  |                                                      |                                   | Normanton No. 4 (btms) |                                    |                                    |                 |                                  |                     |                  |                           |                          |                     |                         |                            | Top or Working                   |                        |                | Little Jim                       |                         | Little Jim                 |
| Roots             |                  | Unnamed                                              |                                   |                        |                                    |                                    |                 |                                  |                     |                  |                           |                          |                     |                         |                            |                                  |                        |                |                                  |                         | Roots                      |
| Joynson           |                  | New Malabar                                          | Rosemount No. 4                   | New Malabar            | New Malabar                        | New Malabar                        |                 | New Malabar                      | New Malabar         | ? New Malabar    | Top or New Malabar        | New Malabar              | New Malabar         | New Malabar             |                            |                                  |                        |                | Middle and Rosewood No. 2 Bottom | New Malabar             | Joynson                    |
| Boughen           |                  |                                                      |                                   |                        |                                    |                                    |                 |                                  |                     |                  |                           |                          |                     |                         |                            | Bottom                           | ? Mount Elliott Bottom |                | Seam 53 ft below the Bottom      |                         | Boughen                    |
| Butler            |                  |                                                      | Lanefield No. 5                   | ? Lanefield No. 5      |                                    | Oakleigh Airshaft                  | Lanefield No. 5 | Oakleigh Airshaft                | United No. 8 Top    |                  | Bottom or Lanefield No. 5 | United No. 8 Top         | United No. 8 Top    | United No. 8 Top        |                            | Moorefield No. 3 Top             | Top                    |                | Oakleigh Airshaft                | Lanefield No. 5         | Butler                     |
| Cowell            | Lower            |                                                      |                                   |                        |                                    |                                    |                 | United No. 8 Bottom              | United No. 8 Bottom |                  |                           | United No. 8 Bottom      | United No. 7 Top    | United No. 7 Top        |                            | Moorefield No. 3 Bottom          | Bottom                 |                |                                  |                         | Cowell                     |
| Stewart           |                  |                                                      |                                   |                        |                                    |                                    |                 |                                  |                     |                  |                           |                          |                     |                         | Westvale No. 7             |                                  |                        |                |                                  |                         | Stewart                    |
| Kathage           |                  |                                                      |                                   |                        |                                    |                                    |                 |                                  |                     |                  |                           |                          |                     |                         |                            |                                  |                        |                |                                  |                         | Kathage                    |
| Wass              |                  | Lowfield                                             | Lowfield                          | ? Lowfield             |                                    |                                    | Lowfield        | Lowfield                         | Lowfield            | ? Lowfield       | Lowfield                  | New Mountain View Top    | United No. 7 Bottom | Roughrigg No. 5 Working | Lowfield No. 2 Top or Clay | Lowfield                         |                        | Working        | Lowfield                         | Caledonian No. 5 (tops) | Wass                       |
| Haenke            |                  |                                                      |                                   |                        |                                    |                                    | Middle          |                                  | Seam below Lowfield |                  |                           | New Mountain View Bottom |                     |                         |                            | Lowfield No. 2 Bottom            |                        |                |                                  |                         | Caledonian No. 5 (bottoms) |
| Bruce             |                  |                                                      | Westvale No. 5                    |                        |                                    |                                    | Westvale No. 5  |                                  | Westvale No. 5      |                  |                           |                          |                     |                         |                            |                                  |                        |                |                                  | Westvale No. 5          | Bruce                      |
| Rea               |                  |                                                      |                                   |                        |                                    |                                    |                 |                                  |                     |                  |                           |                          |                     |                         |                            |                                  |                        |                |                                  |                         | Rea                        |
| References        | Hawthorne, 1954b | Hawthorne, 1954a<br>Cameron, 1963h<br>Cameron, 1963i | Cameron, 1956<br>Chiu Chong, 1962 | Cameron, 1959          | Cameron, 1960<br>Chiu Chong, 1963d | Cameron, 1961a                     | Cameron, 1961b  | Cameron, 1961c<br>Cameron, 1962d | * Cameron, 1962a    | Cameron, 1962b   | Cameron, 1962c            | Cameron, 1963a           | Cameron, 1963b      | Chiu Chong, 1963a       | Chiu Chong, 1963b          | Cameron, 1963c<br>Cameron, 1963d | Cameron, 1963e         | Cameron, 1963f | Cameron, 1963g                   | Chiu Chong, 1963c       | References                 |







**REA SEAM**

In those parts of the coalfield tested by diamond drilling, the lowest worked seam in the succession lies 90 to 130 feet above the base of the Walloon Coal Measures. This seam appears to have been exploited first in the late 1880's by John Nicol Rea at Caledonian Colliery (No. 1 Shaft) and so the name Rea Seam is here applied. It should be noted that as early as 1881, a seam occupying a somewhat similar stratigraphic position was worked at Old Walloon Colliery, about 2 miles further east. However, the identity of the seam there is by no means certain and so its selection as a reference section for nomenclatural purposes was not considered.

The Rea seam has been worked at the following collieries:—

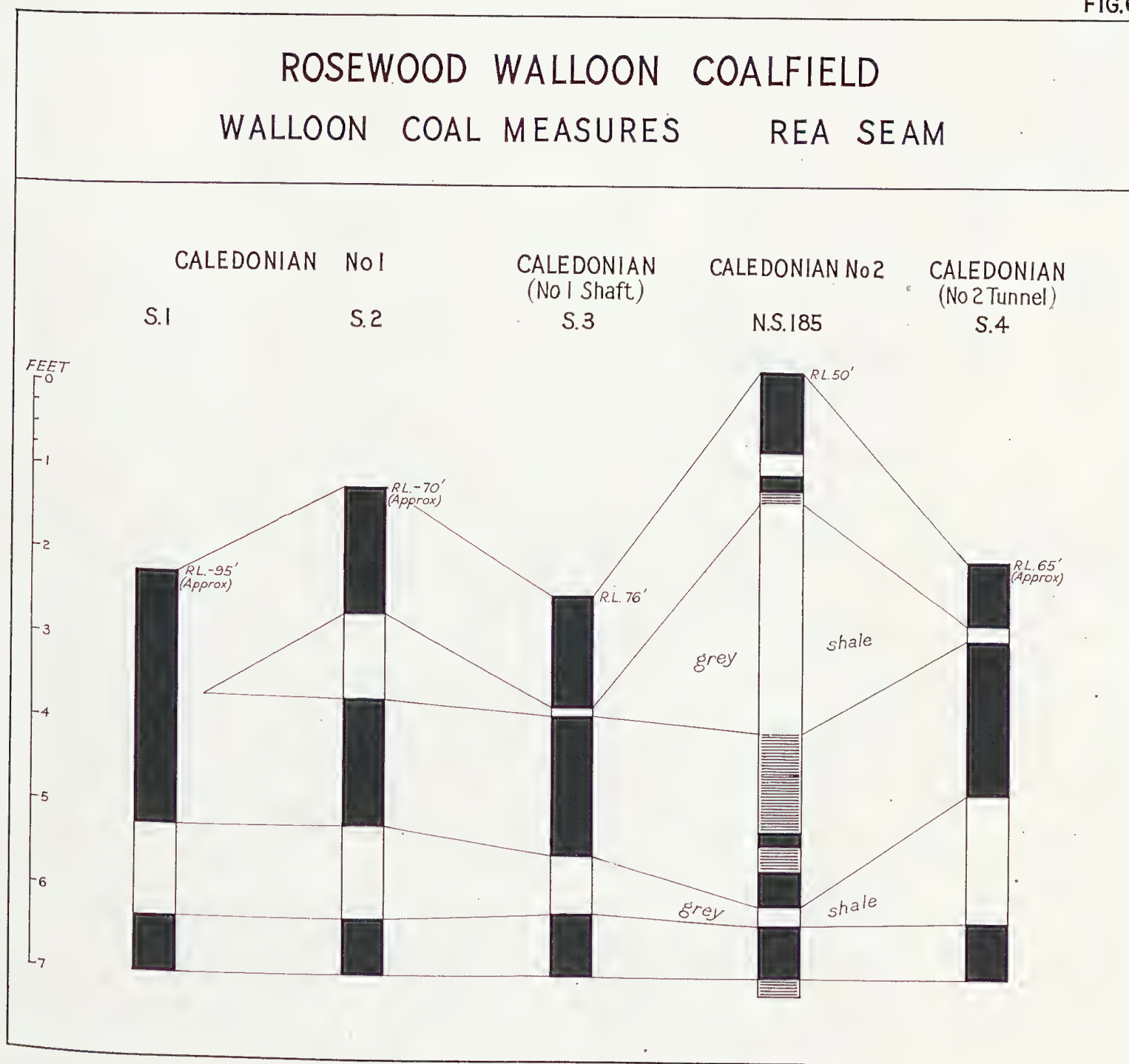
*Abandoned*—Caledonian (No. 1 Shaft, No. 1 Tunnel, No. 2 Shaft, No. 2 Tunnel), Caledonian No. 1, Caledonian No. 2.

*Working*—none; the seam was last worked at Caledonian No. 2 Colliery in 1946.

All these collieries are adjoining and are situated in the Thagoona-Walloon district of the coalfield.

In the Thagoona-Walloon district where it is typically developed, the Rea seam is generally about 5 feet thick and comprises three fairly uniform sections of coal separated by two grey shale beds of varying thickness; the lower of these lies 8 to 9 inches above the floor of the seam and the upper about 1 foot 4 inches below the roof (see figs. 6 and 24). It would appear that in the old Caledonian pits, the Rea seam

FIG.6





was rendered unworkable by the thickening of one or both of these grey shale interbeds, although in diamond drillhole N.S. 185, some 10 chains beyond the most north-westerly workings, deterioration of the middle coal ply to carbonaceous shale also occurs.

In the other parts of the coalfield which have been tested by diamond drilling, the Rea seam can generally be recognized because of its stratigraphic position and lithologic character. Nowhere, however, is the seam of economic interest, such is the thickness of its shale interbeds. In some areas, this separation of the coal beds is so great that the seam loses its identity completely, the constituent coal plies forming but part of the sequence of thin beds of coal which normally underlies the Rea seam for 30 to 50 feet.

### BRUCE SEAM

The name Bruce seam is here applied to the seam of coal first worked in 1918 by John Mitchell Bruce at Lanefield No. 1 Colliery (No. 1 Tunnel). In those parts of the coalfield tested by diamond drilling, the seam generally lies 50 to 60 feet above the Rea seam.

The Bruce seam has been worked at the following collieries:—

*Abandoned*—Caledonian No. 3 (?), Clydebank No. 5 (previously Westvale No. 4 and Ardath), Lanefield No. 1 (No. 1 Tunnel, No. 2 Tunnel, Old Tunnel, New Tunnel), Lanefield No. 2, Lanefield No. 4, Lanefield Extended No. 1, Lanefield Extended No. 2, Westvale No. 3, Westvale No. 5 (No. 1 Tunnel, No. 2 Tunnel).

*Working*—None; the seam was last worked in Westvale No. 5 Colliery in 1957.

With the exception of Caledonian No. 3 Colliery which lies in the Thagoona-Walloon district, all these collieries are situated in the Lanefield district of the coalfield.

In the vicinity of Lanefield No. 1 Colliery (No. 1 Tunnel) the Bruce seam is about 4 feet 6 inches thick and comprises two main sections of coal separated by a 6 inch bed of grey shale which lies approximately 1 foot from the roof (see fig. 7). The bottom 3 foot section of coal is particularly clean and the top coal contains only one thin shale bed. In other parts of the Lanefield district, however, the lower section of the seam is generally split into three coal plies by two additional grey shale beds of varying thickness; the lower of these lies about 1 foot 6 inches from the bottom of the section and the upper some 4 inches from the top. Towards the south-west, an additional coal ply, 9 to 10 inches thick, lies only 6 to 11 inches below the normal seam floor and so was included there in the working section. In most of the pits in which it was exploited in the Lanefield district, the Bruce seam was rendered unworkable by the thickening of one or more of these grey shale interbeds.

Because of its stratigraphic position and lithologic character, the Bruce seam can generally be recognized in the other parts of the coalfield which have been tested by diamond drilling. In these areas, however, the seam is of no economic interest because of the thickness of its shale and siltstone interbeds. In places, this splitting of the seam is so considerable that the constituent coal plies cannot be distinguished with certainty from the thin beds of coal which normally lie both below and above the seam. Such is the case at Caledonian No. 3 Colliery in the eastern part of the coalfield; the seam exploited there has been tentatively correlated with the upper coal plies of the Bruce seam.

### HAENKE SEAM

In the north-western part of the coalfield, some 40 to 50 feet above the Bruce seam, there occurs a persistent seam of coal which is here named the Haenke seam. This coal was first worked at Westvale No. 6 Colliery in 1948 by Westvale Collieries, a family firm with which Martin William Haenke was actively associated for many years.

The Haenke seam has been worked at the following collieries:—

*Abandoned*—New Amberfield (?), New Mountain View No. 3, Lowfield No. 2, United No. 7, Westvale No. 6. In addition, at Westvale No. 8 Colliery, an air-shaft was sunk to the Haenke seam and a tunnel driven but the seam was never exploited because of the croppy nature of the strata.

*Working*—none; the seam was last worked in United No. 7 Colliery in 1965.

With the exception of New Amberfield Colliery which is situated in the Amberley district all these collieries lie in the Bluff and Tallegalla districts in the north-western part of the coalfield.

As demonstrated by the programme of exploratory diamond drilling, the Haenke seam is best developed in the United No. 8, New Mountain View No. 3, and United No. 7 mine areas. In this region the seam is generally about 5 feet thick and comprises three main sections of coal (see fig. 8). The bottom coal which is some 1 foot 6 inches thick and, in places, contains a thin bed of grey or carbonaceous shale is separated from the rest of the seam by a bed of grey shale of varying thickness. Between the middle and top sections of coal, which are approximately 1 foot 3 inches and 1 foot thick respectively, there are two beds of shale separated by a persistent 2 to 4 inch coal ply. The lower grey shale member of this "double band", as it is called in United No. 7 Colliery, is of varying thickness, but the upper member which is light grey or fawn in colour is nowhere more than 1 to 2 inches thick. These beds, therefore, serve as a useful marker for identification of the Haenke seam.

In Westvale No. 6, Lowfield No. 2, and New Mountain View No. 3 Collieries, only the middle and top sections of coal of the Haenke seam were



FIG. 7

FIG. 7

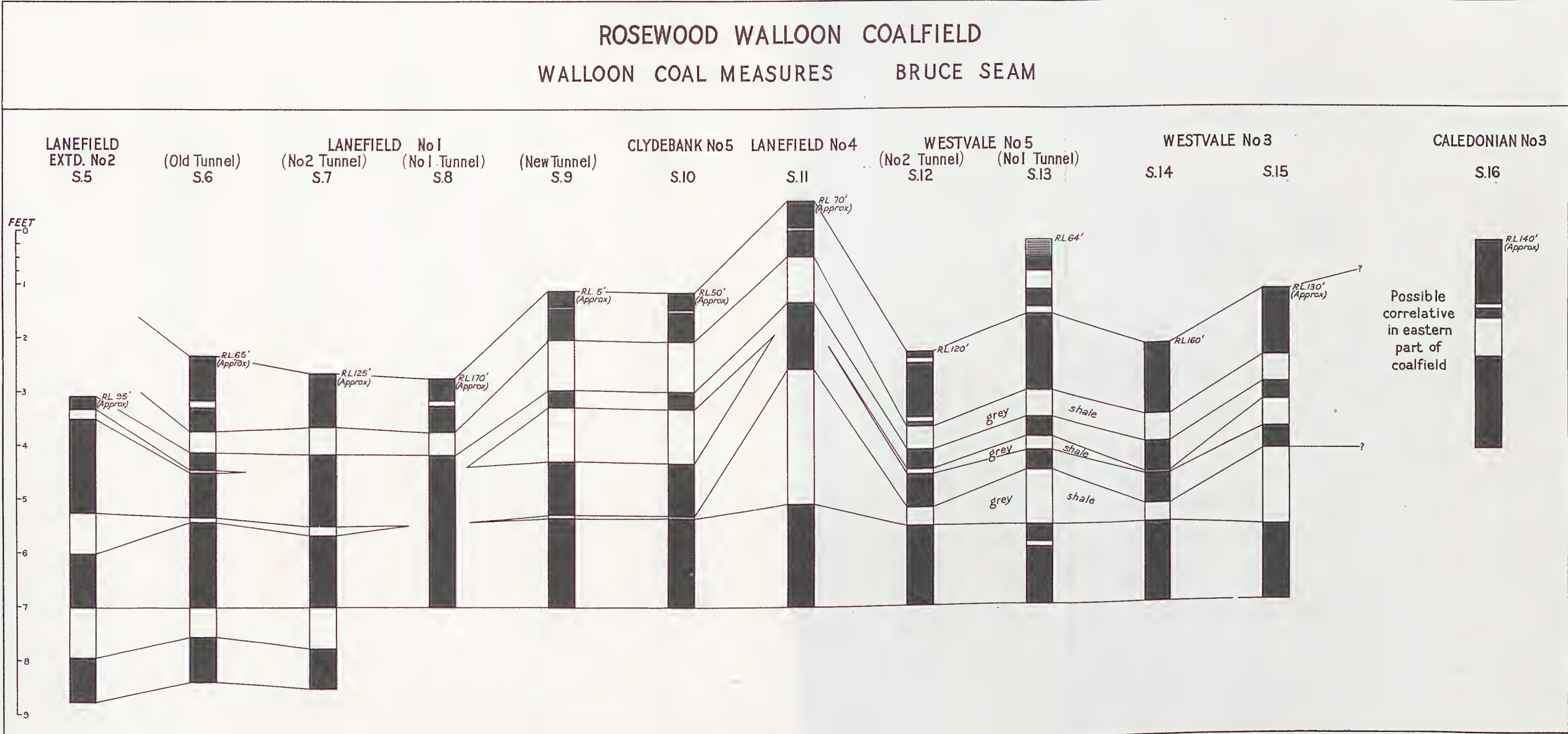






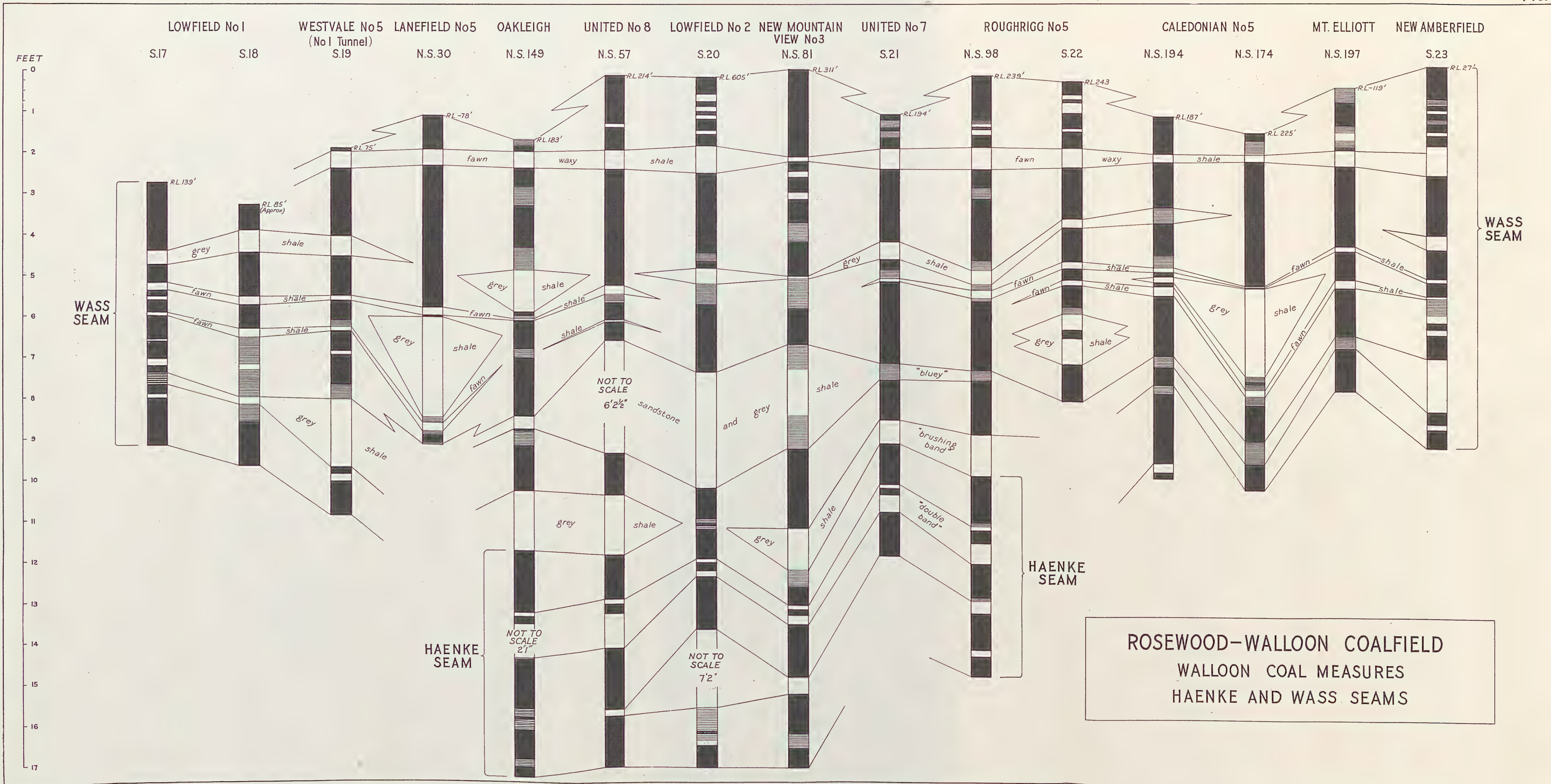






FIG. 8

FIG. 8





exploited, the bottom coal in most places being split off by too great a thickness of shale. For instance, in diamond drillhole N.S. 151 near Lowfield No. 2 Colliery there are over 7 feet of sandstone and shale between the bottom and middle sections of coal. In all three pits, however, the bottom section of coal of the immediately overlying Wass seam was included in the working section. A similar section was also mined in United No. 7 Colliery, where not only the bottom but the lower two sections of coal of the Wass seam were included.

In the north-western part of the coalfield, the Haenke seam can be recognized without difficulty because of its stratigraphic position and lithologic character. Outside the mine areas mentioned, however, the seam is of no economic interest because of the thickness of its two major grey shale interbeds—the shale between the bottom and middle coal and the lower member of the “double band”. In the other parts of the coalfield which were tested by diamond drilling, the Haenke seam is generally poorly developed owing to seam splitting, and deterioration and thinning of its constituent coal plies. In these areas, recognition of the seam has not been attempted except at New Amberfield Colliery where the bottom seam which was worked in the period 1958 to 1960 is tentatively correlated with the Haenke seam.

### WASS SEAM

The name Wass seam is here applied to the persistent seam of coal which generally lies no more than 3 feet above the Haenke seam. In those parts of the coalfield where the Haenke seam cannot be recognized with certainty, the Wass seam lies some 60 to 70 feet above the Bruce seam. The earliest exploitation of what is definitely known to be the Wass seam was by William Wass in 1925 at Lowfield No. 1 Colliery, but as early as 1915 a seam with much the same stratigraphic position and lithologic character was worked at Caledonian No. 1 Colliery about 4 miles further east. However, the identity of the seam there has not been definitely established and so it was not selected as a reference section for nomenclatural purposes.

The Wass seam has been worked at the following collieries:—

*Abandoned*—Caledonian No. 1 (?), Caledonian No. 4 (previously Mount Marrow), Caledonian No. 5, Caledonian No. 6, Lanefield No. 5, Lowfield No. 1, Lowfield No. 2, New Amberfield (previously Amberfield), New Mountain View No. 3, Roughrigg No. 5, United No. 7, Westvale No. 5 (No. 1 Tunnel), Westvale No. 6. In addition, at Westvale No. 8 Colliery, an airshaft was sunk to the Wass seam and a tunnel driven but the seam was never exploited because of the croppy nature of the strata.

*Working*—United No. 8.

As indicated by the distribution of the above collieries, exploitation of the Wass seam throughout the coalfield has been fairly widespread.

In the vicinity of Lowfield No. 1 Colliery the Wass seam is 6 feet 6 inches thick and lies approximately 70 feet above the Bruce seam. It is separated by some 20 feet of sandstone and shale with a few thin coal plies from an underlying unworkable seam of coal the identity of which has not been established, but which may be a correlative of the Haenke seam. In those parts of the coalfield, however, where the Haenke seam is well developed, there is generally less than 3 feet of shale between the two seams, which thus constitute a sequence of coal and shale beds about 15 feet thick. In fact, in several collieries in the north-western part of the coalfield, the Haenke and Wass seams are sufficiently close together for the section exploited to incorporate coal plies from both seams, the intervening shale being looked upon as just another interbed. Such is the case in parts of United No. 7 Colliery where the Haenke and Wass seams are separated by about 6 inches of grey shale, called locally the “brushing band”. Likewise, in New Mountain View No. 3 Colliery, there is as little as 3 inches of grey shale between the two seams and in Westvale No. 6 and Lowfield No. 2 Collieries only 3 inches of carbonaceous shale.

Despite its close association with the Haenke seam, the Wass seam does possess sufficient lithologic character to be readily identified as a separate unit in all parts of the coalfield tested by diamond drilling. This is due mainly to the presence within the seam of several thin beds of fawn, waxy shale composed essentially of montmorillonite clay. Because of their characteristic lithology, lateral persistence, and uniform thickness, these beds serve as useful markers for the identification of the seam as a whole and also of its constituent coal plies. This is so particularly with the topmost bed which is about 6 inches thick and lies within 2 feet of the roof of the seam. The Wass seam is stratigraphically the lowest seam in the Walloon Coal Measures where beds composed largely of montmorillonite clay form such an important and diagnostic part of the seam section. As in the underlying seams, however, lenticular beds of grey kaolinitic shale also occur on several well-defined horizons.

Throughout the coalfield, the lowest persistent shale bed in the Wass seam lies about 1 foot 3 inches above the floor (see fig 8). In Lowfield No. 1 Colliery, this interbed is represented by about 3 inches of carbonaceous shale; such is the case also in United No. 7 Colliery, where it is called the “bluey band”, and in the Caledonian No. 5 and Mount Elliott mine areas. Elsewhere, the interbed is of grey shale and generally of such thickness that the underlying bottom section of coal cannot be worked along with the rest of the Wass seam. In Westvale No. 6, Lowfield No. 2, and New Mountain View No. 3 Collieries, however, this bottom coal section of the Wass seam was exploited along with the middle and top sections of coal of the Haenke seam, there being in these pits, as previously mentioned, as little as 3 inches of shale between the two seams.



Approximately 1 foot 6 inches above the basal carbonaceous or grey shale interbed in the Wass seam there are two thin beds of fawn, waxy shale, each 1 to 2 inches thick. These beds are separated by a persistent 6 inch coal ply and so serve as a useful marker for identification of the neighbouring coal sections. Generally, the 1 foot 6 inches of coal, which underlies these two fawn shale beds is of good quality, but in certain parts of the coalfield it deteriorates to carbonaceous shale, particularly in its upper portion. This condition exists in small areas in Lowfield No. 1, New Mountain View No. 3, United No. 7 and New Amberfield Collieries. Also in Roughrigg No. 5 Colliery this section of coal, although otherwise of good quality, contains two lenticular grey shale beds with a total thickness of about 1 foot. In Lanefield No. 5 and Caledonian No. 4, 5 and 6 Collieries, a lenticular bed of grey shale also occurs in the coal between the two fawn shale marker beds. Although it has no counterpart in the other parts of the coalfield which have been tested by diamond drilling, this lenticular shale bed is, in the collieries mentioned, of considerable importance as its thickness is in some places in excess of 10 feet.

About 2 feet 6 inches above the two fawn shale beds in the Wass seam there occurs another persistent bed of fawn, waxy shale approximately 6 inches thick. Throughout the coalfield, this bed is by far the most reliable marker for identification of the Wass seam. In most areas, the 2 to 3 feet of coal which underlies this 6 inch fawn shale bed contains one thin bed of grey shale, generally less than 6 inches thick. In the eastern part of United No. 7 Colliery, this grey shale interbed is over 2 feet thick and, as a result, the full section of the Wass seam cannot be exploited. However, that part of the seam below the 2 foot shale bed was worked in conjunction with the middle and top coal sections of the immediately underlying Haenke seam. The Wass seam is most severely split on this horizon in the Oakleigh mine area, where in diamond drillhole N.S. 44 the interbed is almost 20 feet thick.

The 6 inch bed of fawn shale in the Wass seam is overlain by up to 2 feet of coal with several thin beds of carbonaceous and dark grey shale; in the southern part of Caledonian No. 5 Colliery near diamond drillholes N.S. 155 and N.S. 157, a lenticular bed of grey shale up to 3 feet thick also occurs. As a result of lensing and, in limited areas, penecontemporaneous erosion of its upper coal and shale members, the thickness of this topmost coal section is, in most parts of the coalfield, considerably less than 2 feet. In fact, in certain areas, the top coal is not represented at all as, for example, in parts of Westvale No. 5 Colliery. In the adjacent Lowfield No. 1 Colliery where the Wass seam was first exploited, only the bottom 4 to 5 feet of the seam was worked and so no detailed information is available about the upper coal beds. However, the reduced seam thickness of 6 feet 6 inches suggests that there the top section of coal is likewise not represented for, in most parts of the coalfield where the complete section is developed, the Wass seam is 7 to 8 feet thick.

In all parts of the coalfield where detailed sub-surface information is available, the Wass seam can be readily recognized because of its stratigraphic position and lithologic character. Not everywhere, however, is the seam of economic interest because of excessive splitting by its grey shale interbeds or deterioration of its constituent coal plies to carbonaceous shale. Nevertheless, as demonstrated by the diamond drilling programme, comparatively large areas of potentially workable coal still exist in the Wass seam at Lanefield No. 5 and Mount Elliott No. 1 Extended Collieries.

### KATHAGE SEAM

In the Mount Marrow district of the coalfield, a persistent seam of coal occurs above the Wass seam at intervals varying from 3 to 23 feet. This coal was first worked in 1932 by August Kathage at Westfalen No. 1 Colliery and so is here named the Kathage seam.

The Kathage seam has been worked at only one colliery:—

*Abandoned*—Westfalen No. 1.

*Working*—none; the seam was last worked in Westfalen No. 1 Colliery in 1948.

In Westfalen No. 1 Colliery the Kathage seam is 5 to 6 feet thick and comprises three main sections of coal (see fig. 9). The bottom and middle coal sections are 1 foot 2 inches and 6 inches thick respectively and are separated by a persistent bed of fawn, waxy shale generally about 2 inches thick. Between these lower two coal plies and the 1 foot 8 inch top section of coal there is a variable sequence of interbedded carbonaceous shale, coal and fawn shale which ranges in thickness from 1 foot 3 inches to almost 3 feet.

Although poorly developed to the west of Rosewood and in the Amberley district, the Kathage seam, because of its stratigraphic position and lithologic character, can generally be recognized without much difficulty in the other parts of the coalfield which have been tested by diamond drilling. However, only one area of potentially workable coal was found in the seam during the complete programme of coal exploration; this is also in the Mount Marrow district about 2 miles to the north of the Westfalen No. 1 Colliery and 20 to 30 chains north-west of Caledonian No. 6 tunnel. Elsewhere, the seam is of no economic interest because of deterioration of certain of its coal plies to carbonaceous shale and the presence, particularly in the north-western part of the coalfield of one or two grey shale interbeds in the top section of coal.

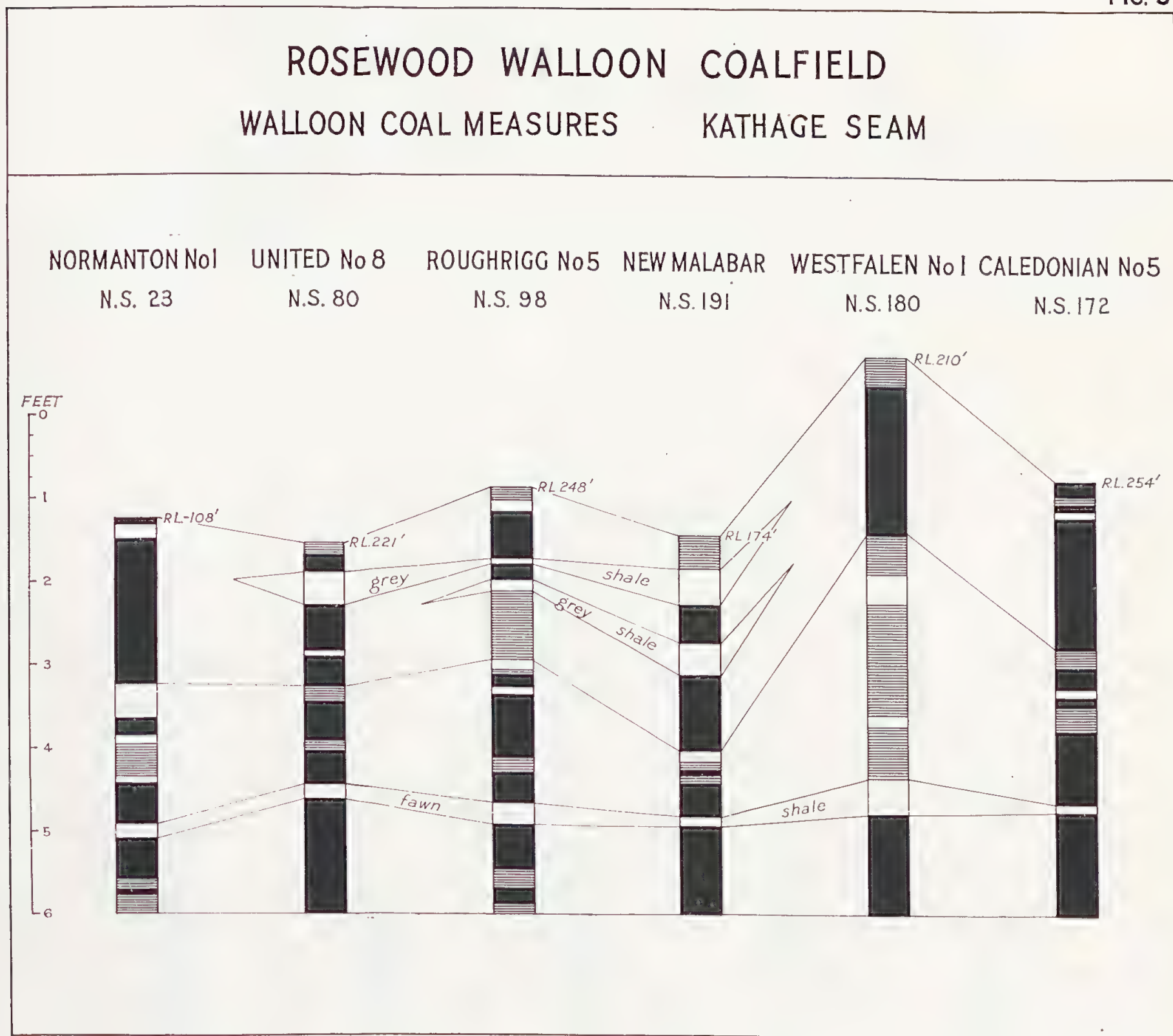
The extreme lenticularity of the detrital sediments of the Walloon Coal Measures is well illustrated by the strata underlying the Kathage seam. In diamond drillholes N.S. 58 and N.S. 98 in the United No. 8 and Roughrigg No. 5 mine areas respectively, there is as



little as 2 to 3 inches of shale between the Wass and Kathage seams. In the intervening area, however, the two seams are separated by a thick bed of sand-

stone, the maximum interval recorded being almost 64 feet in drillhole N.S. 83 in the New Mountain View No. 3 mine area.

FIG. 9



### STEWART SEAM

The name Stewart seam is here applied to the persistent seam of coal which in the north-western part of the coalfield generally lies 10 to 20 feet above the Kathage seam. What is definitely known to be the Stewart seam was first worked at Westvale No. 7 Colliery in 1952 by Westvale Collieries, a firm owned by the Haenke family and of which Charles Stewart was then superintendent. In 1945, a seam occupying

much the same stratigraphic position was worked to a limited extent at Lowfield No. 4 Colliery about 5 chains further west. However, the identity of the seam there has not been established with certainty and so its selection as a reference section for nomenclatural purposes was not considered. It should also be noted that as early as 1924, a seam of coal was worked at Mountain Ash No. 1 Colliery, the bottom 1 foot 6 inches of which is considered to represent the upper part of the Stewart seam.



The Stewart seam has been worked at the following collieries:—

*Abandoned*—Lowfield No. 4 (?), Mountain Ash No. 1 (?), Westvale No. 7. In addition, at Lowfield No. 3 Colliery driving of a tunnel to the Stewart seam was begun, but the seam was never exploited.

*Working*—none; the seam was last worked at Westvale No. 7 Colliery in 1954.

With the exception of Mountain Ash No. 1 Colliery which is situated in the Birru district, all these collieries lie in the Bluff district of the coalfield.

In the Westvale No. 7 Colliery the Stewart seam is about 4 feet 6 inches thick and comprises three main sections of coal (see fig. 10). Between the bottom and middle coal sections, which are 1 foot

4 inches and 1 foot thick respectively, there is a persistent bed of fawn, waxy shale about 3 inches thick. These lower two coal plies are separated from the top 8 inch section of coal by a sequence of grey shale and coal beds up to 1 foot 4 inches in total thickness. Because of the high proportion of shale beds in the section, the Stewart seam in Westvale No. 7 Colliery could not be worked economically and so the pit was abandoned after operating for only a few years.

The Stewart seam is best known in the north-western part of the coalfield where it lies 10 to 20 feet above the Kathage seam. Between the two seams there is a persistent, solitary bed of coal approximately 1 foot thick. This coal generally occurs about 5 feet below the Stewart seam, but in the eastern part of the Roughrigg No. 5 mine area it lies over 20 feet below; in that area the Kathage-Stewart seam interval is 40 to 50 feet.

FIG.10

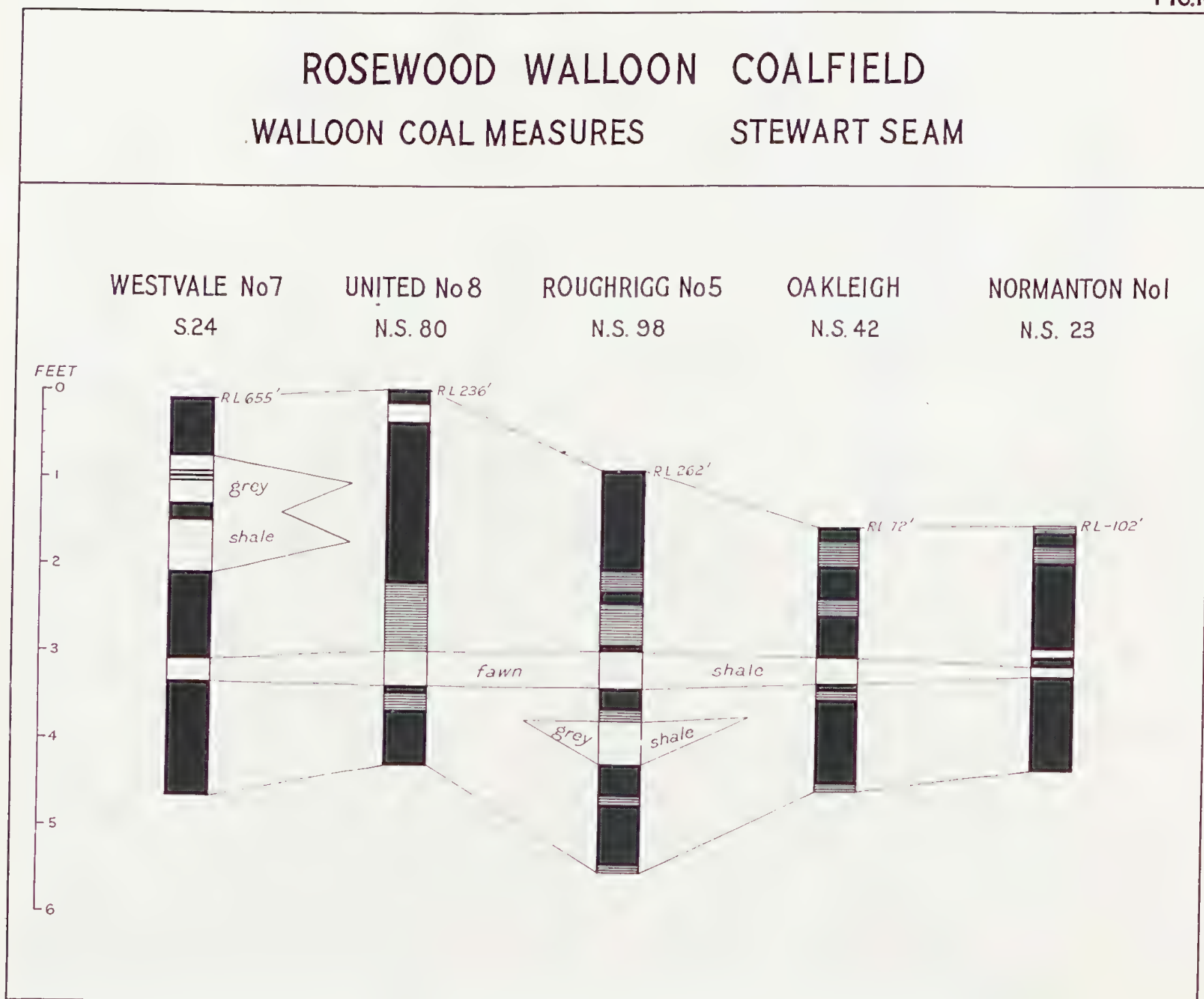




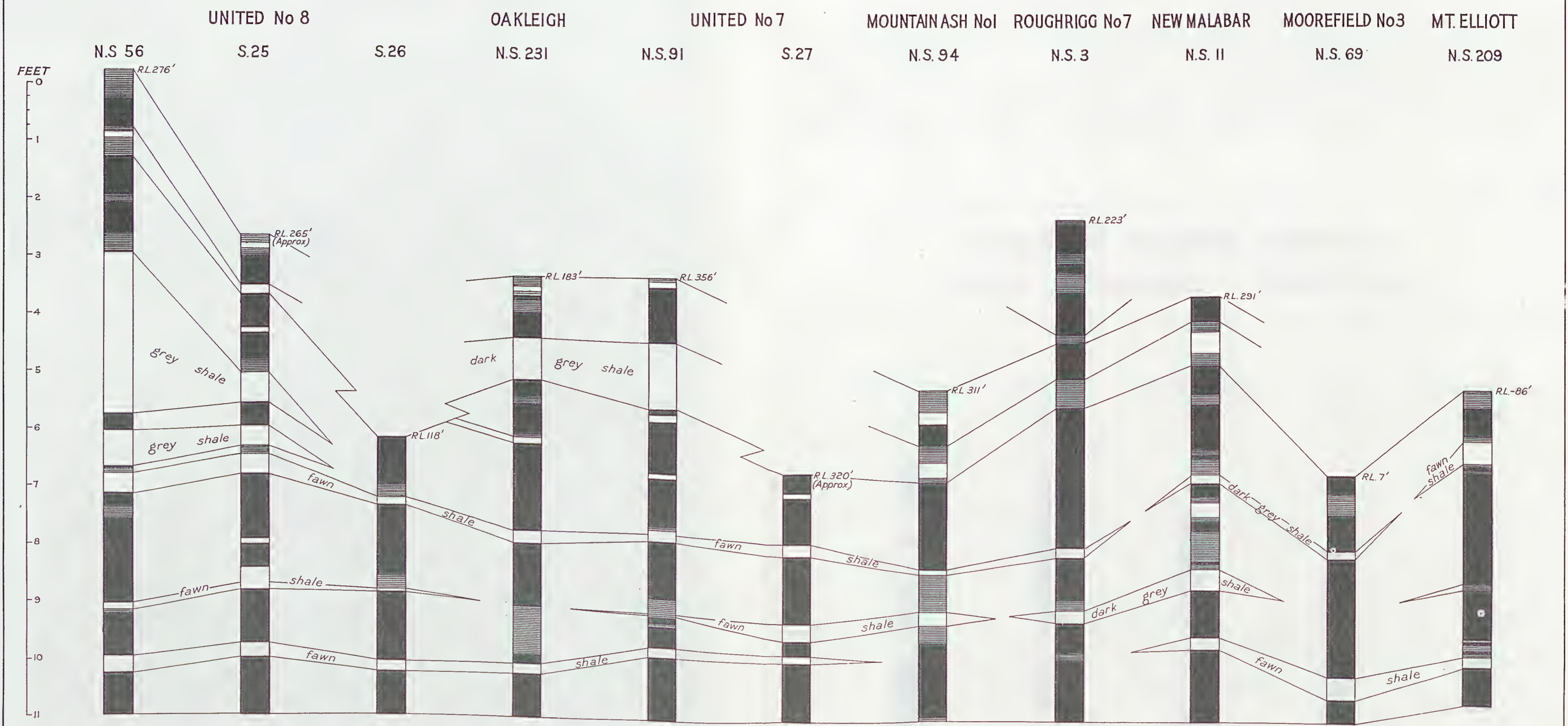




FIG. II

FIG. II

ROSEWOOD WALLOON COALFIELD  
WALLOON COAL MEASURES      COWELL SEAM





In many places in the north-western part of the coalfield, the grey shale beds which separate the middle and top sections of coal in Westvale No. 7 Colliery are not represented and so the Stewart seam is only about 3 feet thick; the 3 inch bed of fawn shale lying approximately in the middle of the seam. In certain localities, however, other lenticular beds of grey shale occur in both the lower and upper coal sections. In the Roughrigg No. 5 mine area, the Stewart seam is severely split by one such interbed, which lies just above the fawn shale marker. This split, which has a maximum recorded thickness of 13 feet in diamond drillhole N.S. 150, apparently extends as far as Mountain Ash No. 1 Colliery. There, the bottom 1 foot 6 inches of the section exploited is believed to represent the upper part of the Stewart seam; the remainder of the worked section is correlated with the overlying Cowell seam. What is considered to be the lower part of the Stewart seam lies several feet below.

Beyond the north-western part of the coalfield, the Stewart seam is poorly developed to the south-east of Mount Marrow and, as is also the case with the Kathage seam, to the west of Rosewood and in the Amberley district. However, in the remaining parts of the coalfield where detailed subsurface information is available, the seam can be recognized without much difficulty because of its stratigraphic position and lithologic character. This is so even in the area between Normanton No. 1 and Rosewood No. 2 Collieries where the interval between the Kathage and Stewart seams is as little as 2 feet. There, the two seams together with the intervening 1 foot bed of coal constitute a sequence of interbedded coal and shale 10 to 15 feet thick.

During the programme of exploratory diamond drilling, not one area of workable coal was found in the Stewart seam. This is not altogether unexpected as the full section of the seam has been worked only in the Bluff district and there, as previously mentioned, its exploitation was not an economic proposition. The Stewart seam could be of interest, however, where it lies sufficiently close to the overlying Cowell seam to allow coal plies from both seams to be worked together, as was done at Mountain Ash No. 1 Colliery. Such conditions exist in the area between United No. 7 and United No. 8 Collieries, where in diamond drillholes N.S. 89, N.S. 91, and N.S. 71 the Stewart and Cowell seams are separated by 1 foot, 1 foot 8 inches, and 1 foot 4 inches of shale respectively.

### COWELL SEAM

Generally no more than 10 feet above the Stewart seam, there occurs in the area between United No. 8 and Roughrigg No. 5 Collieries a persistent seam of coal which is here named the Cowell seam. It is considered that this coal was first worked in 1924 at Mountain Ash No. 1 Colliery in conjunction with the upper part of the Stewart seam. However, as the identity of the seam there has not been established with certainty, it was not selected as a reference section for nomenclatural purposes. The earliest exploitation of what is definitely known to be the Cowell seam was by

William Cowell in 1931, about 30 chains to the south-west at a mine which is now called United No. 7 Colliery.

The Cowell seam has been worked at the following collieries:—

*Abandoned*—Moorefield No. 3, Mountain Ash No. 1 (?), United No. 7 (previously Glassenbury, Tallegalla and Cowell's Tunnel).

*Working*—Oakleigh No. 4, United No. 8. At United No. 8 Colliery, mining operations in the Cowell seam ceased in 1966 but the Wass seam is still being worked.

With the exception of Moorefield No. 3 Colliery which is situated in the Amberley district, all these collieries lie in the north-western part of the coalfield.

The Cowell seam is best known in United No. 8 Colliery where it is 7 to 8 feet thick and comprises five main sections of coal (see fig. 11). Only the bottom four coal sections, however, have been worked; these are referred to locally as the "bottoms", "sugary coal", "middles", and "tops". The "bottoms" and "sugary coal", so called because of its closely spaced cleat, are approximately 10 inches and 1 foot thick respectively and are separated by a persistent bed of fawn waxy shale, 2 to 3 inches in thickness. Above these lower two sections of coal there is a thin bed of fawn shale, up to 2 inches thick, which is generally overlain by about 3 inches of carbonaceous or dark grey shale. The "middles" of the seam are approximately 1 foot 6 inches thick but, in places, they contain 3 to 6 inches of bluey or carbonaceous shale. Between this coal section and the "tops" which can include as much as 1 foot 9 inches of coal, there is a further bed of fawn shale up to 4 inches thick. In the north-western part of the colliery, two lenticular beds of grey shale separated by 5 inches of coal occur immediately above this fawn shale interbed and, as a result, the upper 1 foot 1 inch of coal in the "tops" of the seam is split off from the lower three coal sections by about 2 feet of interbedded shale and coal. In United No. 8 Colliery, the topmost section of coal of the Cowell seam has not been worked; it comprises coal and carbonaceous shale beds with a total thickness of approximately 1 foot and is separated from the "tops" of the seam by up to 6 inches of carbonaceous and dark grey shale.

Throughout the north-western part of the coalfield, the general form of the Cowell seam differs little from that displayed in United No. 8 Colliery. The five main sections of coal are fairly well developed although, in places, deterioration of the "sugary coal" and "middles" of the seam to carbonaceous shale does occur. In such localities, it is not always possible to distinguish between these two coaly sections as the intervening bed of fawn shale is not as persistent as the seam's other fawn shale interbeds. The two lenticular beds of grey shale which occur between the "middles" and "tops" of the seam in the north-western workings of United No. 8 Colliery thicken considerably in the direction of New Mountain View No. 1 and 2



Collieries; in diamond drillhole N.S. 73, for instance, there are almost 13 feet of sandstone and shale between the two coal sections. Splitting of the Cowell seam on this horizon was not detected elsewhere, but in parts of the Oakleigh mine area the topmost section of coal, which generally lies only a few inches above the "tops" of the seam, is split off by up to 7 feet of shale. In several diamond drillholes in the area between Oakleigh No. 4 and Roughrigg No. 7 Collieries, a further 2 feet of coal lie immediately above the Cowell seam; this results in a combined thickness of almost 9 feet. In other localities, however, this coal bed lies several feet above the Cowell seam. The greatest departure from the typical Cowell seam section occurs to the south of United No. 8 Colliery. There, the seam is only 4 to 5 feet thick and has a sandstone roof, its upper coal members having been removed apparently by pene-contemporaneous erosion. Similar conditions exist also in the access tunnel of United No. 7 Colliery.

Where typically developed in the north-western part of the coalfield, the Cowell seam generally lies 5 to 10 feet above the Stewart seam, the intervening strata being shale with a few thin coal plies. In the vicinity of United No. 7 Colliery, however, the two seams are only 1 to 2 feet apart; on the other hand, in parts of the United No. 8 and Roughrigg No. 5 mine areas, they are separated by 20 to 30 feet of sandstone and shale.

Although poorly developed to the west of Rosewood and to the south-east of Mount Marrow, the Cowell seam, because of its stratigraphic position and lithologic character, can be recognized in most other parts of the coalfield which have been tested by diamond drilling. In these areas, seam thickness is generally less than 3 feet as only the lower two or three sections of coal are represented; the upper coal members have been removed apparently by pene-contemporaneous erosion. A more complete section of the Cowell seam, however, occurs in the Amberley district, where, in addition to the lower three sections of coal, approximately 1 foot of the "tops" of the seam is also developed. This results in a seam thickness in some localities of 5 to 6 feet. Beyond the north-western part of the coalfield, the Cowell seam generally lies no more than 10 feet above the Stewart seam, although between Normanton No. 1 and Rosewood No. 2 Collieries there is as much as 30 feet of sandstone and shale between the two seams. In those parts of the coalfield where the Stewart seam cannot be recognized with certainty, as, for example, in the Amberley district, the Cowell seam lies approximately 50 feet above the Wass seam.

In the north-west of the coalfield, areas of workable coal established by the exploration programme still exist in the Cowell seam in the vicinity of Oakleigh No. 4 and Roughrigg No. 5 Collieries. Elsewhere in this region, the seam is rendered unworkable by deterioration to carbonaceous shale of certain of its constituent coal plies, particularly the "sugary coal" and "middles" of the seam. In other parts of the coalfield, the Cowell seam, because of its reduced seam thickness, is of no economic interest, except in

the Amberley district where a large area of good quality coal occurs in the Mount Elliott No. 1 Extended mine area.

### BUTLER SEAM

The name Butler seam is here applied to the seam of coal first worked in 1907 at Bedworth Colliery (later called Excelsior Colliery). It has not been possible to identify the principals of the Bedworth Coal Co., but the mine manager at that time was J. W. Butler. Generally throughout the coalfield the Butler seam lies between 20 and 40 feet above the Cowell seam, the intervening strata being mainly shale with one persistent but variable coal seam 2 to 3 feet thick. In those parts of the coalfield where the Cowell seam is poorly developed and cannot be readily recognized, and this is the case in the vicinity of Excelsior Colliery, the Butler seam lies approximately 70 feet above the Wass seam.

The Butler seam has been worked at the following collieries:—

*Abandoned*—Amberley No. 1, Coalfields (previously Lawrielfield and United No. 3), Excelsior (previously Bedworth), Lanefield No. 3 (previously Arndt's Tunnel), Lanefield No. 5, Moorefield No. 3 (previously Amberley No. 2), Moorefield No. 4, Oakleigh No. 3, Rosemount No. 4.

*Working*—Glencoe Extended No. 1, Oakleigh No. 4, United No. 8. At Oakleigh No. 4 and United No. 8 Collieries mining operations in the Butler seam ceased in 1968 and 1954 respectively, but other seams are still being worked, the Cowell seam at Oakleigh No. 4 Colliery and the Wass seam at United No. 8 Colliery.

As indicated by the distribution of the above collieries, exploitation of the Butler seam throughout the coalfield has been fairly widespread.

Over most of the area tested by diamond drilling the Butler seam consists of three sections of coal separated by two persistent beds of grey shale of variable thickness (see fig. 12). The bottom coal is usually about 2 feet thick and may contain several thin shale beds. The middle coal, which is the main component of the seam, is 3 to 4 feet thick and generally of good quality. There is invariably present in this section a thin median bed of grey shale or carbonaceous shale which in places thickens considerably; in the northern workings of Lanefield No. 5 Colliery it is represented by nearly 2 feet of grey shale. In addition, two other less persistent beds of grey shale develop in certain parts of the coalfield. One, up to 8 inches in thickness, occurs from 6 to 10 inches above the floor in the area between Oakleigh No. 4 and Roughrigg No. 5 Collieries. The other occurs at United No. 8 Colliery; it has a maximum thickness of just over 1 foot and lies about 9 inches below the roof of the middle coal. The top coal is the most variable



FIG. 12

FIG12

ROSEWOOD WALLOON COALFIELD

WALLOON COAL MEASURES BUTLER SEAM

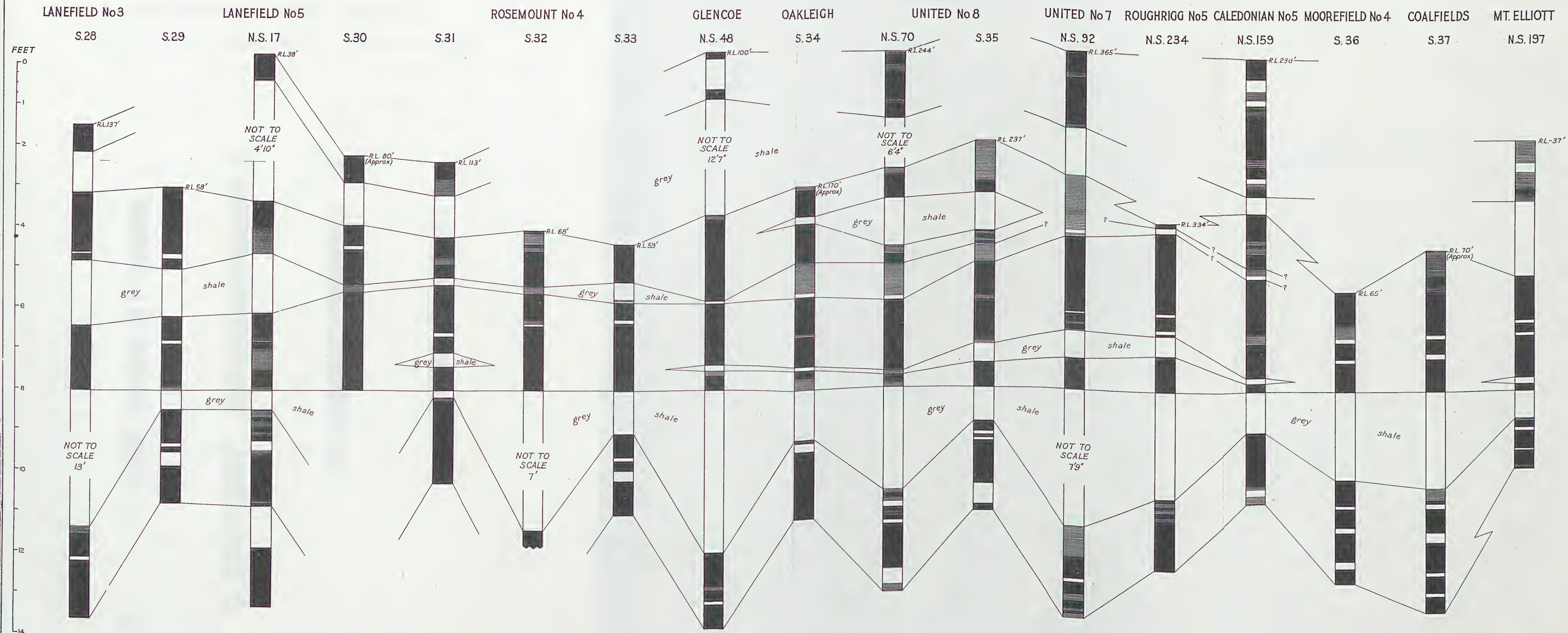


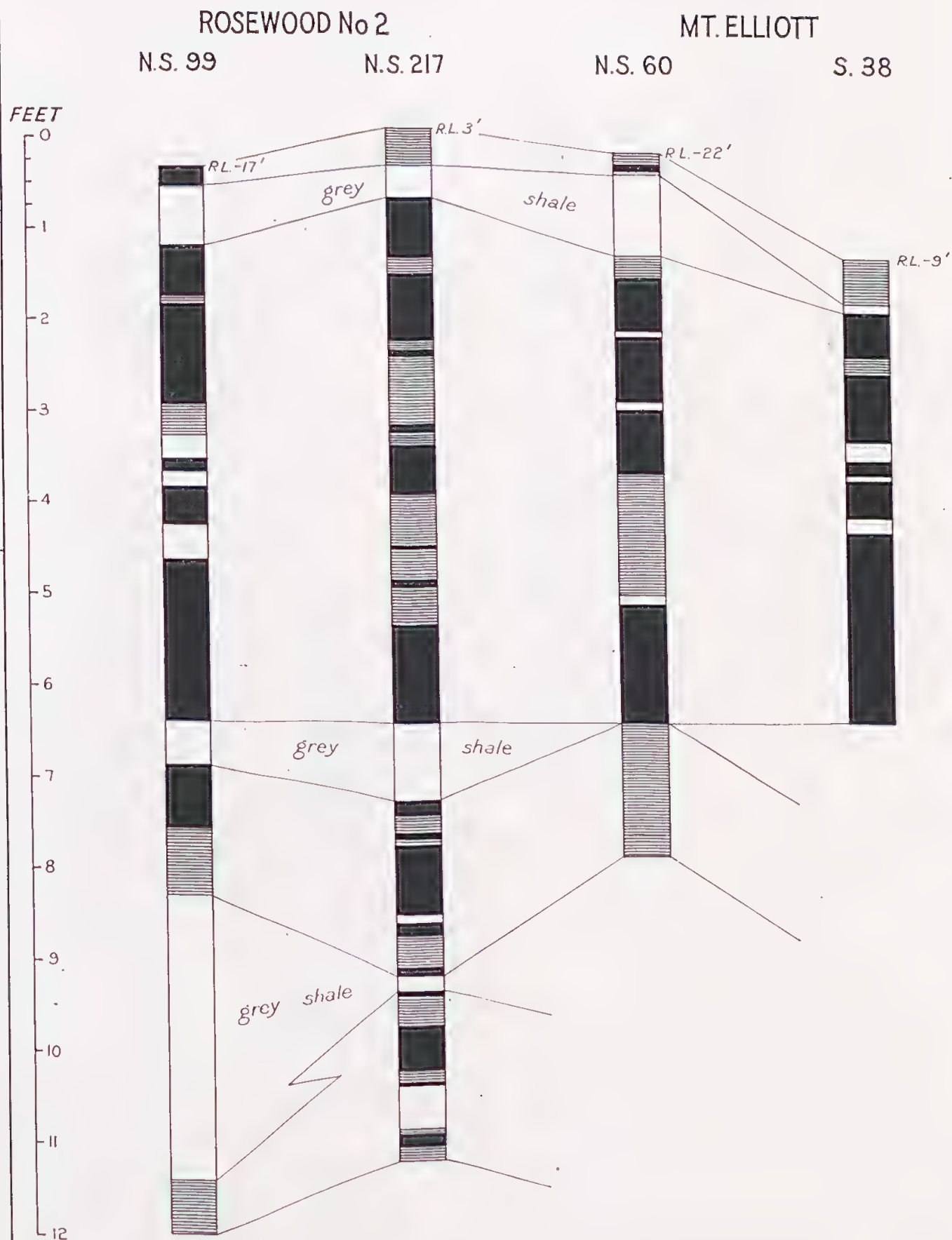






FIG.13

ROSEWOOD WALLOON COALFIELD  
WALLOON COAL MEASURES BOUGHEN SEAM





of all three coal sections, ranging in thickness from a few inches to 3 feet; in parts of the Amberley district it is not developed at all.

The lower persistent grey shale interbed in the Butler seam varies in thickness from a few inches to 20 feet. It is only when it is of manageable thickness that both the bottom and middle coals can be included in the worked section. The upper grey shale interbed is generally several feet thick and in only a few places is it sufficiently thin for the top coal to be exploited along with the rest of the seam. Such was the case near Oakleigh No. 4 Colliery airshaft and around drillhole N.S. 50 in the Glencoe Extended No. 1 mine area. In all other localities where the Butler seam has been exploited, it is the bottom and middle coals which constitute the worked section.

Throughout the coalfield the Butler seam can be readily recognized because of its stratigraphic position and lithologic character. In most localities it is of little economic interest because of excessive splitting or prior exploitation.

### BOUGHEN SEAM

In the late 1940's when the airshaft at Rosewood No. 2 Colliery was deepened as a prospecting venture, a potentially workable seam of coal was penetrated about 50 feet below the Joynson seam. To this coal the name Boughen seam is now applied as James Boughen was associated with the firm operating Rosewood No. 1 and 2 Collieries for many years. The Boughen seam has not been worked at Rosewood No. 2 Colliery; its earliest exploitation appears to have been in 1958 at Mount Elliott No. 1 Extended Colliery in the Amberley district. Because of its isolated position in the coalfield, the identity of the seam there has not been established beyond doubt and so its selection as a reference section for nomenclatural purposes was not considered. Throughout most of the coalfield the Boughen seam is poorly developed, but where it can be recognized it lies 20 to 30 feet above the Butler seam.

The Boughen seam has been worked at the following collieries:—

*Abandoned*—none.

*Working*—Mount Elliott No. 1 Extended (?).

In addition at Rosewood No. 2 Colliery an airshaft was sunk to the Boughen seam, but the coal was never exploited.

Where first penetrated in the airshaft at Rosewood No. 2 Colliery, the Boughen seam is reported to be over 7 feet thick, but split by a 2 foot shale bed into 4 feet of top coal and 1 foot 3 inches of bottom coal, both of these sections containing several thin shale beds. There is little similarity between this reported section and those penetrated in nearby drillholes N.S. 99 and 217 (see fig. 13). In those holes, the Butler seam is about 11 feet thick and besides three persistent beds of grey shale contains a high proportion of carbonaceous shale. The Boughen seam at Mount Elliott No. 1 Extended Colliery exhibits a section

similar to the upper elements of the seam at Rosewood No. 2 Colliery, but it is mainly on the basis of their similar stratigraphic positions that the two seams are correlated.

### JOYNSON SEAM

In the vicinity of Rosewood Nos. 1 and 2 Collieries a persistent seam of coal lies approximately 50 feet above the Boughen seam. This coal was first worked in 1932 by Ernest Joynson at Rosewood No. 1 Colliery and so is here named the Joynson seam. In those parts of the coalfield where the Boughen seam is poorly developed and cannot be readily recognized the Joynson seam lies at intervals ranging from 60 to 100 feet above the Butler seam.

The Joynson seam has been worked at the following collieries:—

*Abandoned*—Malabar No. 4, Malabar No. 6, Malabar No. 7, Malabar No. 8, Malabar No. 9, New Malabar No. 1, New Mountain View No. 1 (previously Mountain View No. 1), New Mountain View No. 2 (previously Mountain View No. 2), Norman-ton No. 2 (?), Oakleigh No. 3, Rosemount No. 1 (?), Rosemount No. 4, Rosewood No. 1.

*Working*—Glencoe Extended No. 1, Norman-ton No. 1, Rosewood No. 2. At Glencoe Extended No. 1 Colliery mining operations in the Joynson seam ceased in 1963, but the Butler seam is still being worked.

All these collieries are situated in the area between Rosewood and Malabar.

In all parts of the coalfield tested by the drilling programme, the Joynson seam displays a very uniform pattern of behaviour. Generally the seam is divisible into two distinct sections of coal, although in some localities an additional coal ply up to 1 foot thick lies within a few inches of the normal floor (see fig. 14). This is so particularly at Rosewood No. 2 Colliery where this underlying coal was included in the worked section. The bottom of the two main sections of coal is about 2 feet thick and is separated from the top coal by a persistent bed of grey shale which varies in thickness from a few inches to several feet. The top section of coal where fully developed is 4 to 5 feet thick and includes two persistent beds of grey shale, approximately 1 foot and 2 feet respectively from the base, and one equally persistent bed of fawn shale about 3 feet from the base. These beds of grey and fawn shale are generally only 1 to 2 inches thick, but in some localities the grey shale beds thicken considerably. In parts of Oakleigh No. 3 and Glencoe Extended No. 1 Collieries the lower of these two grey shale beds is almost 1 foot thick; in Rosewood No. 2 and New Malabar No. 1 Collieries the upper grey shale bed is as much as 6 feet and 3 feet thick respectively. It is only in parts of Rosemount No. 4 and the latter two collieries that the top section of coal is completely developed. In other parts of the



FIG.14

FIG.14

ROSEWOOD WALLOON COALFIELD  
WALLOON COAL MEASURES      JOYNSON SEAM

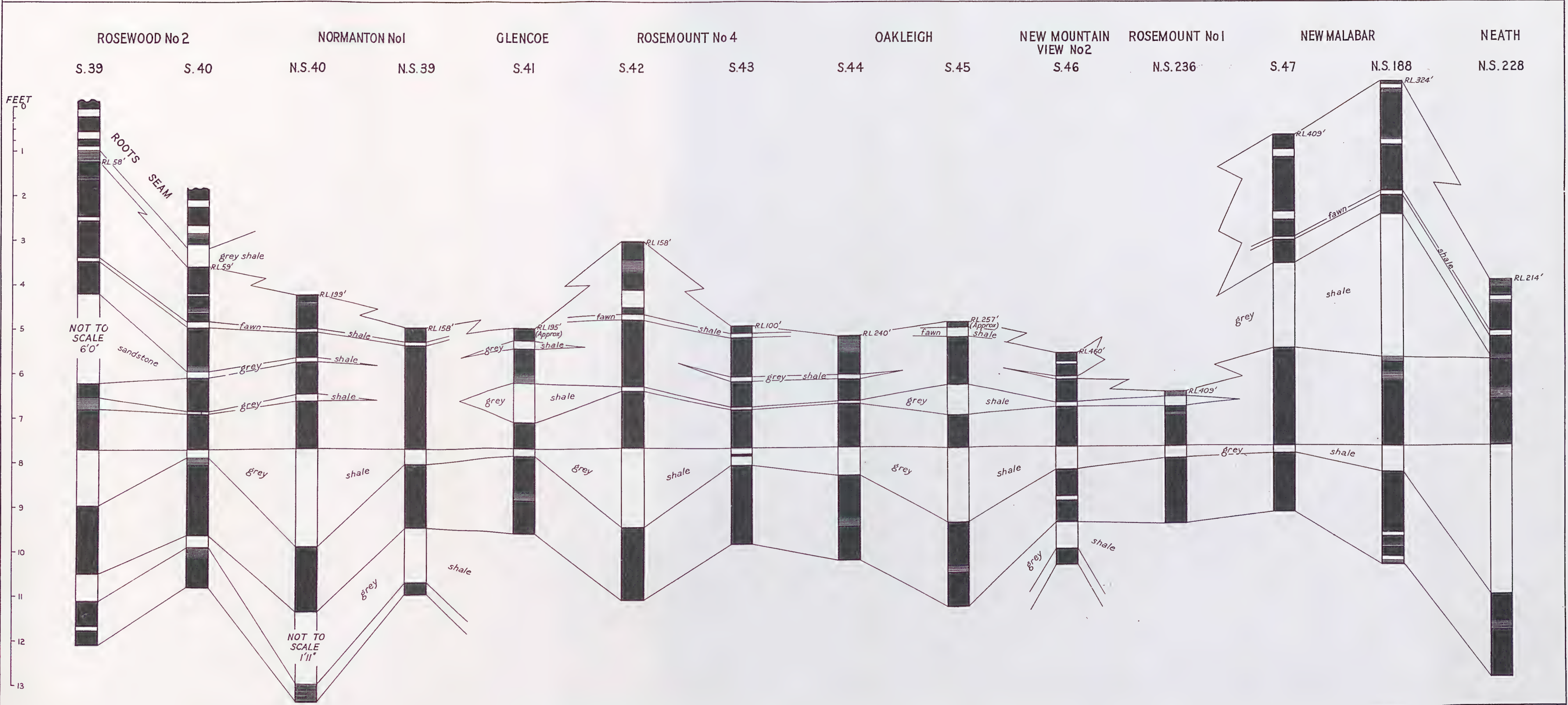












FIG.15

FIG.15

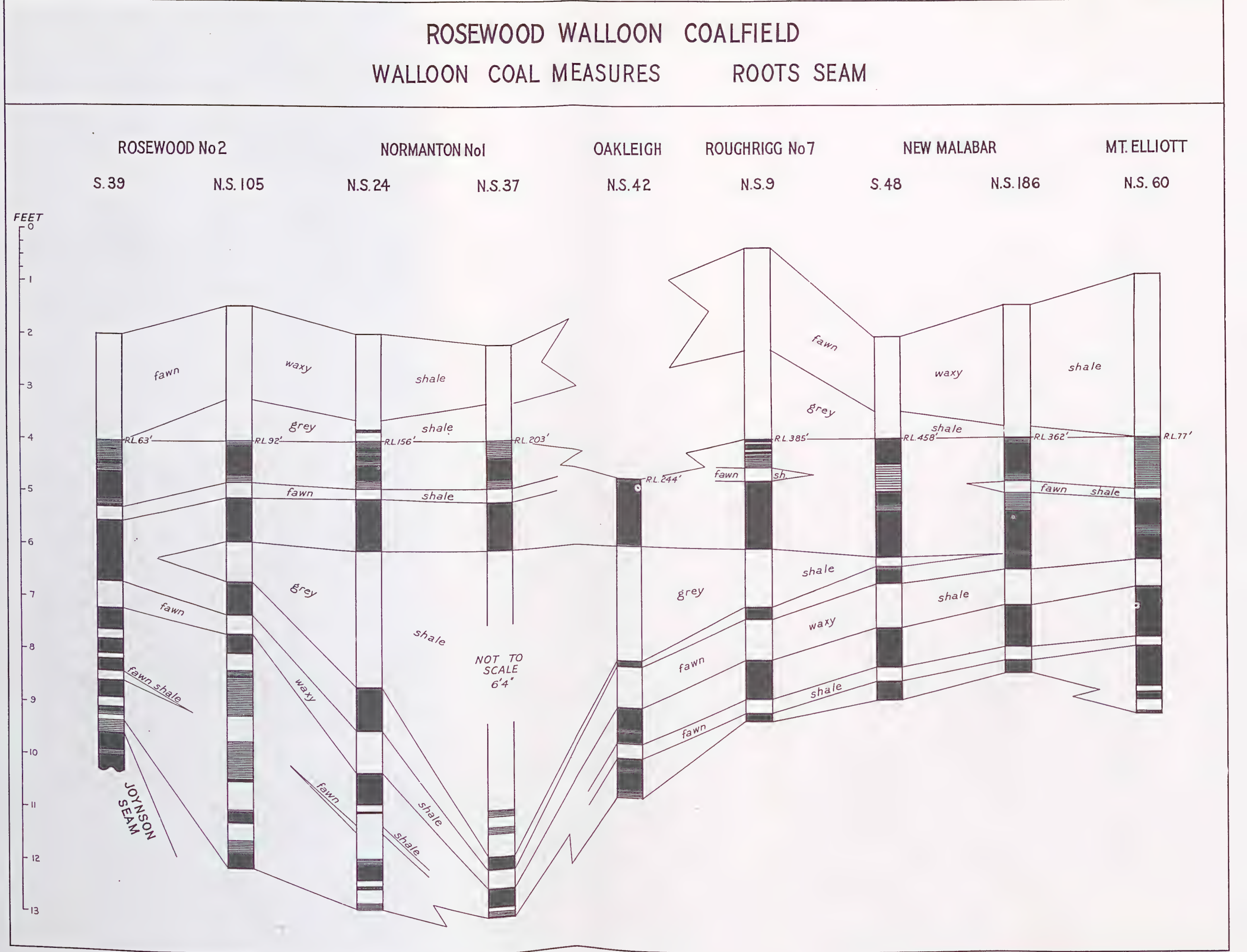


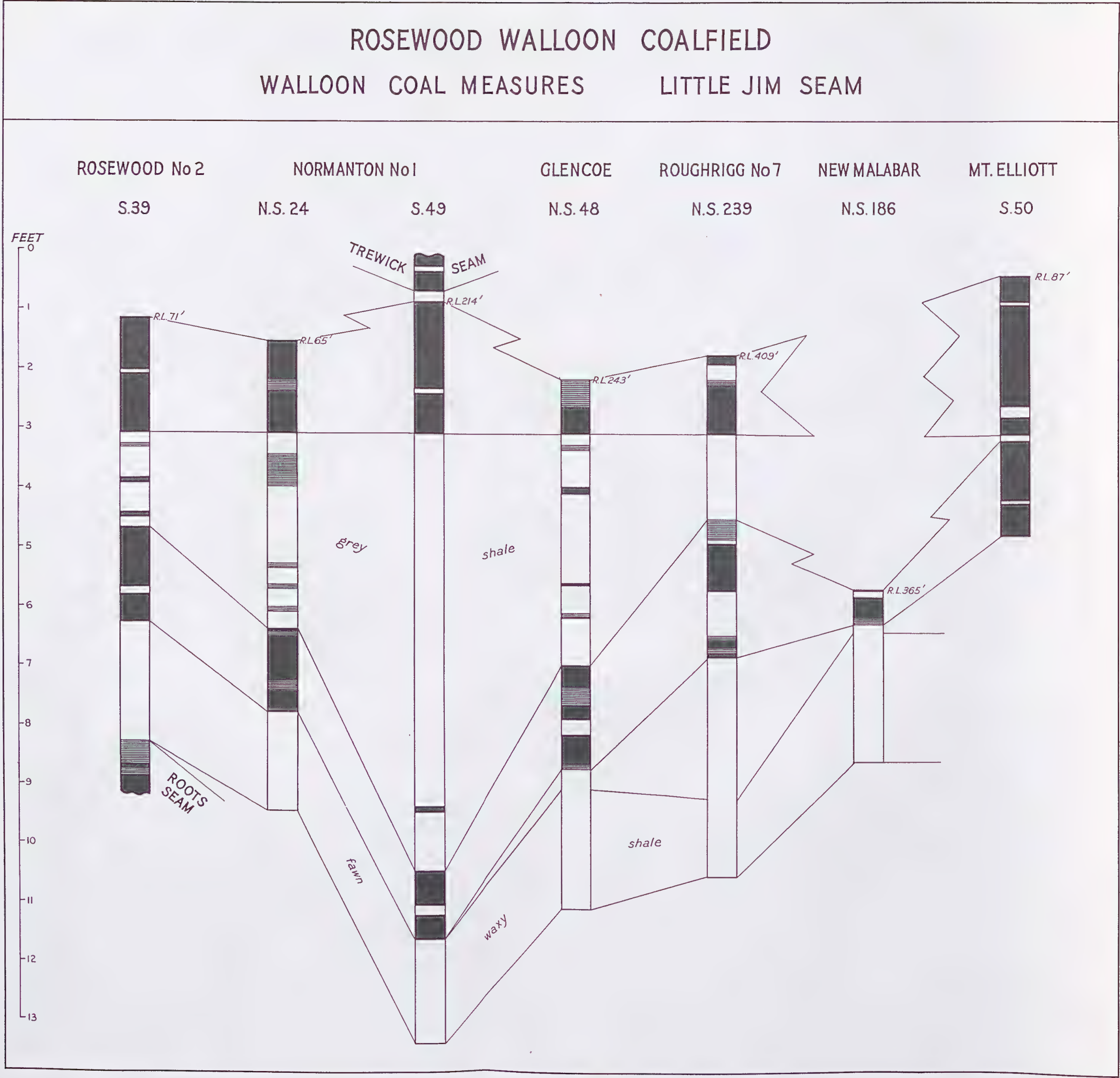






FIG.16

FIG.16





coalfield the top coal is only 2 to 3 feet thick; the coal plies above the persistent fawn shale bed and even up to 1 foot below it in places are replaced in the stratigraphic sequence by sandstone beds.

Generally the section worked in the Joynson seam comprises the bottom coal and as much of the top coal as is developed in that locality. In Rosewood No. 2 Colliery however, where the upper grey shale bed in the top section of coal is in places represented by about 6 feet of sandstone, two separate sections in the Joynson seam were exploited. These sections lying below and above the thick sandstone bed were referred to locally as the Bottom and Middle seams. It is possible that the latter section includes some of the lower coal plies of the immediately overlying Roots seam.

Recognition of the Joynson seam throughout the coalfield usually presents no problem, even where the seam is unworkable because of thickening of one or more of its grey shale interbeds. As demonstrated by the exploration programme the Joynson seam is of little economic significance because of excessive splitting or prior exploitation.

### ROOTS SEAM

The name Roots seam is here applied to the seam of coal which was first successfully exploited in 1961 by Noel Horace Roots at the Malabar Minerals Bentonite Mine (Cameron, 1963i). In fact, the seam was worked only to allow extraction of an immediately overlying 2 foot bed of montmorillonite clay. In the early 1950's at Oakleigh No. 3 Colliery, an attempt was made to work the Roots seam as a source of coal, but this proved unsuccessful. Throughout the coalfield the interval between the Joynson and Roots seams varies from a few inches to nearly 50 feet.

The Roots seam has been worked at the following collieries and mine:—

*Abandoned*—Oakleigh No. 3.

*Working*—Malabar Minerals Bentonite Mine (previously New Malabar No. 1), Oakleigh No. 4. At Oakleigh No. 4 Colliery mining operations in the Roots seam ceased in 1963, but the Cowell seam is still being worked.

Where typically developed, the Roots seam is 5 feet thick and is separated into two distinct sections of coal by a median grey shale bed only a few inches in thickness (see fig. 15). The bottom coal section includes two persistent beds of fawn shale, a 2 to 3 inch bed only a few inches from the base, and another of waxy appearance about 9 inches thick up to 9 inches from the top. The top section of coal and carbonaceous shale also includes a persistent bed of fawn shale 2 to 3 inches in thickness about 1 foot from the base. In certain localities the grey shale bed between the bottom and top coal sections thickens considerably; in drillhole N.S. 93 in the United No. 7 mine area the Roots seam is split on this horizon by over 30 feet of shale and sandstone.

Generally the Roots seam is immediately overlain by a 2 foot bed of fawn waxy shale which is composed mainly of montmorillonite clay, but in places a lenticular bed of grey shale up to several feet thick occurs between the two units.

Because of their lithological character and stratigraphic position the Roots seam and the overlying bed of montmorillonite clay can be readily recognized throughout the coalfield and so serve as useful stratigraphic markers. In a few isolated localities, however, as in drillhole N.S. 42 in the Oakleigh No. 4 mine area, the bed of montmorillonite clay and even the upper coal plies of the Roots seam have been removed apparently by penecontemporaneous erosion, their place in the stratigraphic column being taken by a thick bed of sandstone on an eroded base.

### LITTLE JIM SEAM

The Little Jim seam was first worked in the early 1920's by John Mitchell Bruce at Bruce's Tunnel, but it was not until this pit was reopened as Rosewood No. 1 Colliery in 1931 by James Boughen and Ernest Joynson that the coal became known as the Little Jim seam. This name has been retained because of the pre-emption of the names Bruce, Boughen, and Joynson for lower seams in the succession. In certain parts of the coalfield the Roots and Little Jim seams are separated by only 2 feet of montmorillonite clay; elsewhere, because of the development of grey shale and sandstone beds both below and above the clay, the two seams are up to 35 feet apart.

The Little Jim seam has been worked at the following collieries:—

*Abandoned*—Mount Elliott No. 1, Mount Elliott No. 2 (previously Bailey's Tunnel), Rosewood No. 1 (previously Bruce's Tunnel).

*Working*—Mount Elliott No. 1 Extended, Normanton No. 1, Rosewood No. 2. At these three collieries mining operations in the Little Jim seam ceased in 1966, 1959, and 1947 respectively, but other seams are still being worked, the Boughen seam at Mount Elliott No. 1 Extended, and the Joynson seam at Normanton No. 1 and Rosewood No. 2 Collieries.

In the access tunnel of Rosewood No. 2 Colliery the Little Jim seam is 5 feet thick and comprises two coal sections separated by 1 foot 6 inches of grey shale with several thin coal beds (see fig. 16). The bottom and top coals are 1 foot 6 inches and 2 feet thick respectively; each contains one thin shale bed. Although in Mount Elliott No. 1 Extended Colliery there is only 1 inch of shale between the two coal sections of the Little Jim seam, in most parts of the coalfield this shale interbed is several feet thick. In the Oakleigh No. 4 and Normanton No. 1 mine areas it is represented by about 25 feet of shale and sandstone; in parts of the latter area, however, the top coal of the Little Jim seam is separated by only 2 inches of grey shale from the overlying Trewick seam and so was included in the worked section.



In some localities the Little Jim seam is not completely developed, its upper components being replaced in the stratigraphic sequence by a thick bed of sandstone. Such is the case in drillhole N.S. 186 in the New Malabar No. 1 mine area.

### TREWICK SEAM

At intervals ranging from a few inches to 25 feet above the Little Jim seam there occurs throughout the coalfield a 3 to 4 foot seam of coal to which the name Trewick seam is here applied. This coal was first worked in 1937 at Normanton No. 1 Colliery by Normanton Collieries, a firm with which Sydney Lyle Trewick was associated for many years.

The Trewick seam has been worked at the following collieries:—

*Abandoned*—Glencoe No. 5, Glencoe No. 6, Malabar No. 1, Malabar No. 2 (previously Mountain Ash No. 2), Malabar No. 3, Malabar No. 5, Malabar No. 10, Roughrigg No. 1, Roughrigg No. 2, Roughrigg No. 3, Roughrigg No. 4, Roughrigg No. 7.

*Working*—Normanton No. 1. At this colliery mining operations in the Trewick seam ceased in 1959, but the Joynson seam is still being worked.

In Normanton No. 1 Colliery, the Trewick seam is approximately 4 feet thick and comprises 2 to 3 feet of bottom coal with several thin grey shale beds in places and up to 1 foot of top coal (see fig. 17). These two coal sections are separated by a persistent bed of greyish white shale arenite about 4 inches thick. In all parts of the coalfield tested by diamond drilling, the Trewick seam displays a very similar section, but lenticular beds of grey shale occur both below and above the greyish white shale arenite. In the northern part of the coalfield between Roughrigg No. 7 and Malabar No. 1 Collieries the grey shale bed beneath the greyish white shale arenite thickens to several feet. This splitting of the seam is invariably accompanied by deterioration to carbonaceous shale and even lensing out of the bottom section of coal. In this area the top section of coal in the Trewick seam is about 1 foot 6 inches thick and is separated from the overlying Gunthorpe seam by only a few inches of grey shale. As a result, the top coal of the Trewick seam was here exploited along with the lower members of the Gunthorpe seam.

As is the case with all the overlying seams, the Trewick seam has been preserved only in the Perry's Knob area and also to the south of the Bremer River between Ebenezer and Amberley. It has been worked only around Perry's Knob, however, and reserves are now depleted.

The Trewick seam occurs at the base of a succession of coal and shale beds between 50 and 60 feet thick. This sequence, which Reid (1921) termed the Rosewood seams, includes the Trewick, Gunthorpe, John, Hardie, Hall, and Hudson seams and lies at the top of the coal-bearing beds of the Walloon Coal Measures.

### GUNTHORPE SEAM

The name Gunthorpe seam is here applied to the persistent seam of coal which generally lies no more than 10 feet above the Trewick seam. This coal was first worked by Westvale Collieries in 1923 at Westvale No. 2 Colliery. Frank Gunthorpe was the mine manager.

The Gunthorpe seam has been worked at the following collieries:—

*Abandoned*—Edenbank, Glencoe No. 5, Glencoe Extended, Lanefield Extended No. 3, Malabar No. 1, Malabar No. 2 (previously Mountain Ash No. 2), Malabar No. 3, Malabar No. 5, Malabar No. 10, Neath No. 1, New Malabar No. 2, Oakleigh No. 1 (previously Duckenfield No. 1), Roughrigg No. 1, Roughrigg No. 2, Roughrigg No. 3, Roughrigg No. 4, Roughrigg No. 7, Smithfield No. 2, Smithfield No. 3, Westvale No. 2.

*Working*—Normanton No. 1. At this colliery mining operations in the Gunthorpe seam ceased in 1960, but the Joynson seam is still being worked.

Where typically developed the Gunthorpe seam is about 6 feet thick (see fig. 18). The bottom section of coal is almost 2 feet thick and contains several thin shale beds, the most persistent and characteristic of which is a 1 inch bed of greyish white shale up to 6 inches from the base. Above the bottom coal is a succession of coal, carbonaceous shale and grey shale beds about 1 foot 6 inches thick. These are overlain by approximately 1 foot 6 inches of clean coal. This middle section of coal is separated by 3 to 4 inches of fawn shale from the top coal which is almost 1 foot thick and contains several thin shale beds.

In the southern part of the Perry's Knob area the complete section of the Gunthorpe seam was worked and in the north-west workings of Normanton No. 1 Colliery the lower part of the overlying John seam was incorporated in the worked section as there was only a few inches of shale between the two seams. In the northern part of the coalfield, however, the Gunthorpe seam is severely split by the thickening of one or more of the grey shale beds in the interbedded coal and shale sequence between the bottom and middle sections of coal. In this area the bottom coal of the Gunthorpe seam is separated by only a few inches of shale from the top coal of the underlying Trewick seam and so thereabouts the worked section comprised these two sections of coal.

In the Mount Elliott No. 1 Extended and Smithfield No. 3 mine areas, the Gunthorpe seam is also split on much the same horizon, the thickening in these areas, however, occurring in the grey shale bed immediately underlying the middle coal. In the northern workings of the latter colliery the middle and top coal sections of the Gunthorpe seam are separated by only a few inches of shale from the overlying John seam and so were incorporated in the worked section.



FIG. 17

FIG. 17

ROSEWOOD WALLOON COALFIELD  
WALLOON COAL MEASURES      TREWICK SEAM

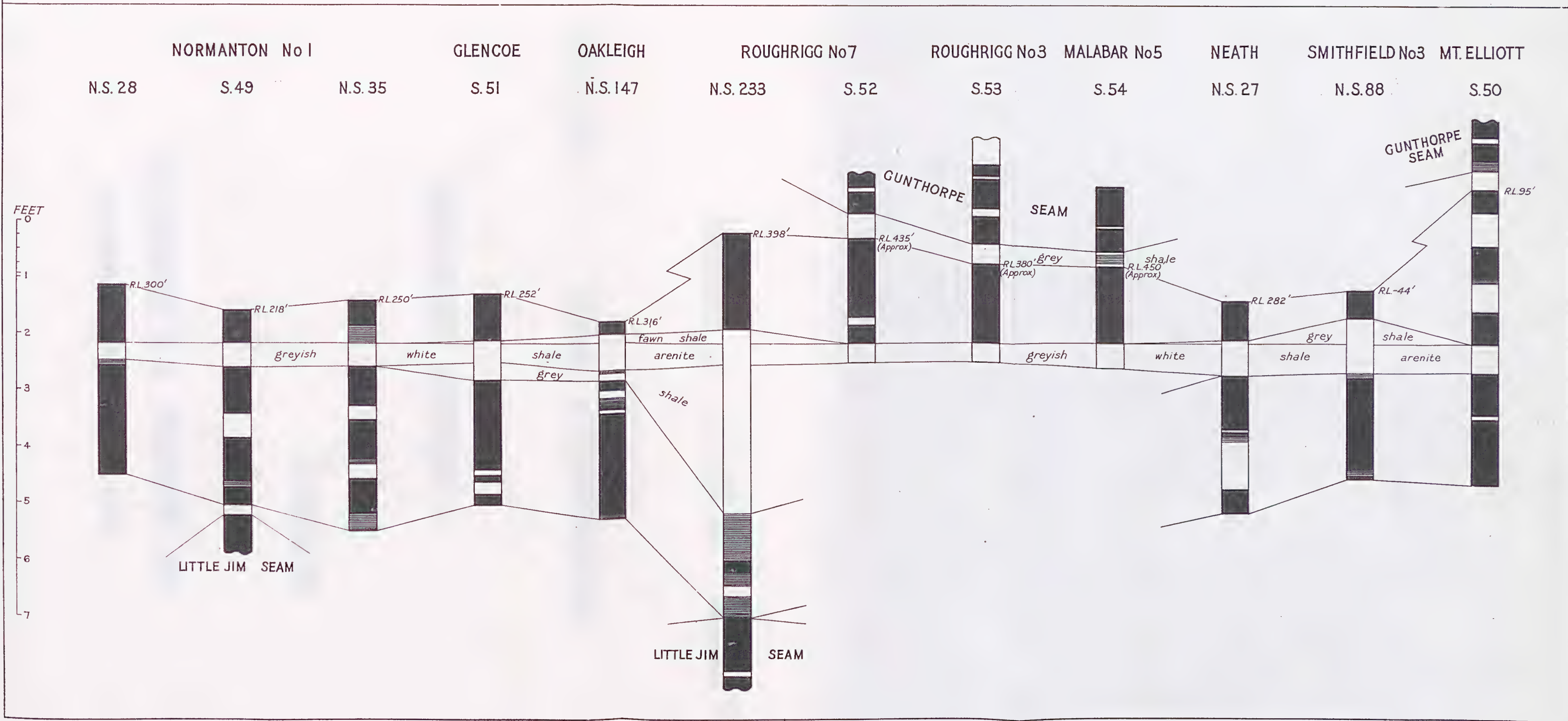








FIG.18

FIG.18

ROSEWOOD WALLOON COALFIELD  
WALLOON COAL MEASURES      GUNTHORPE SEAM

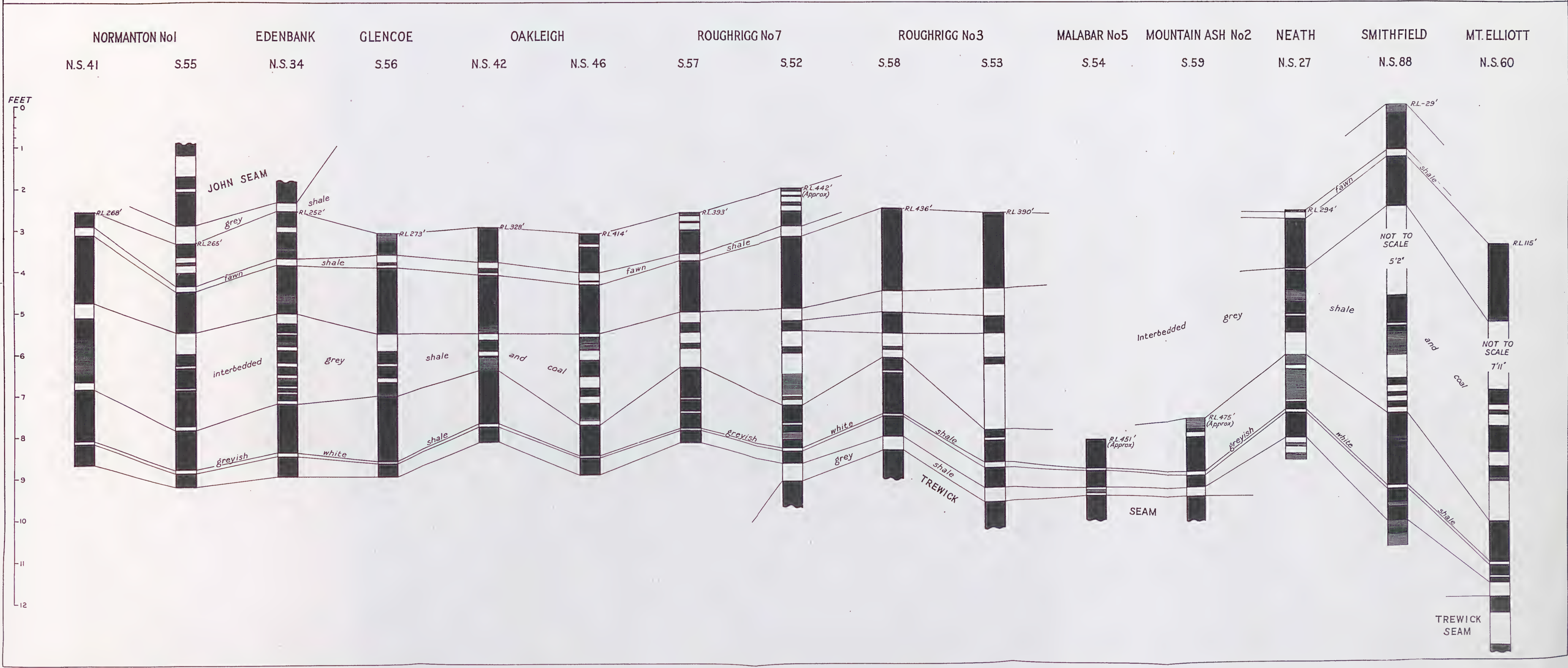












FIG.19

FIG.19

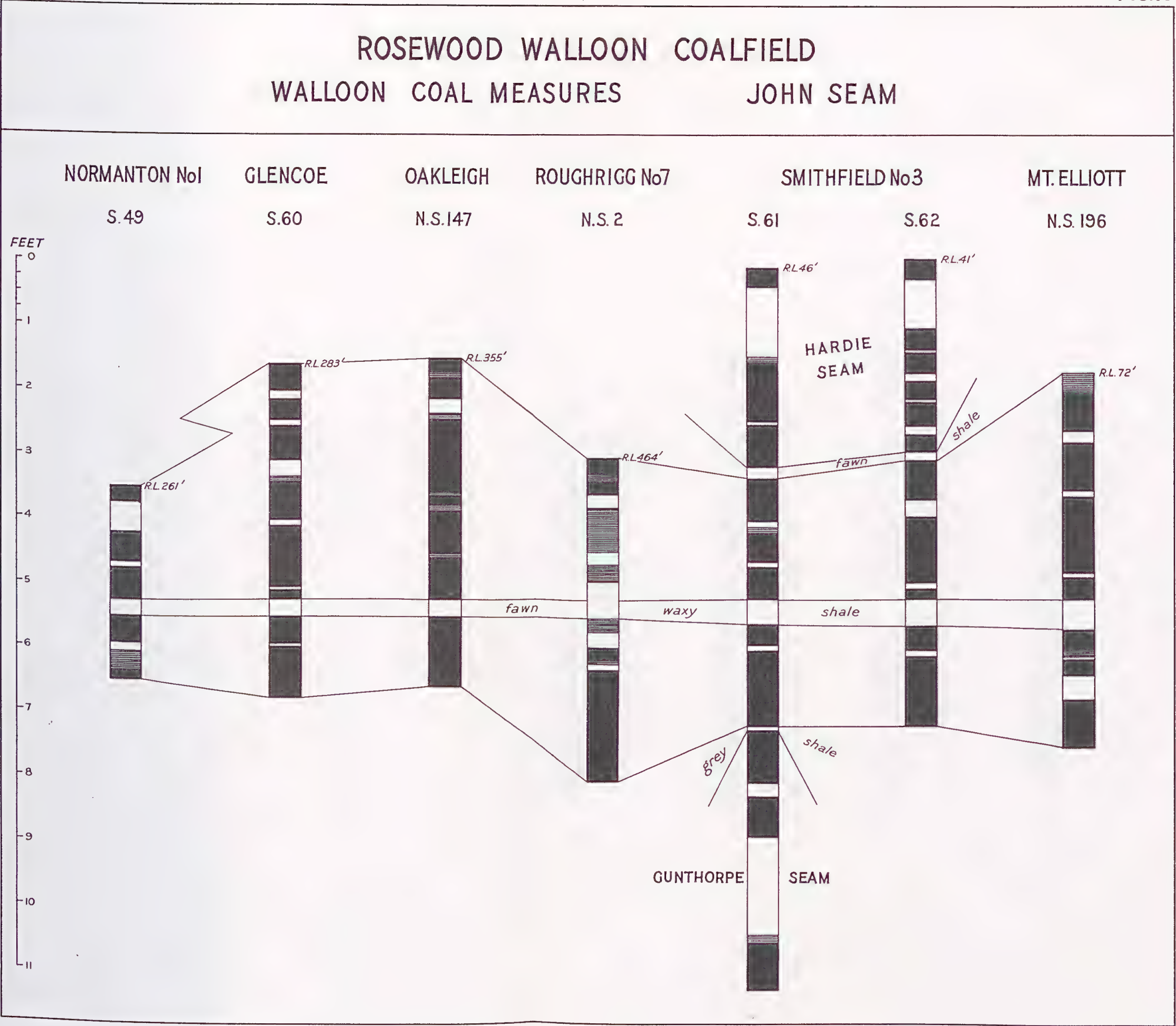








FIG.20

FIG.20

ROSEWOOD WALLOON COALFIELD  
WALLOON COAL MEASURES      HARDIE SEAM

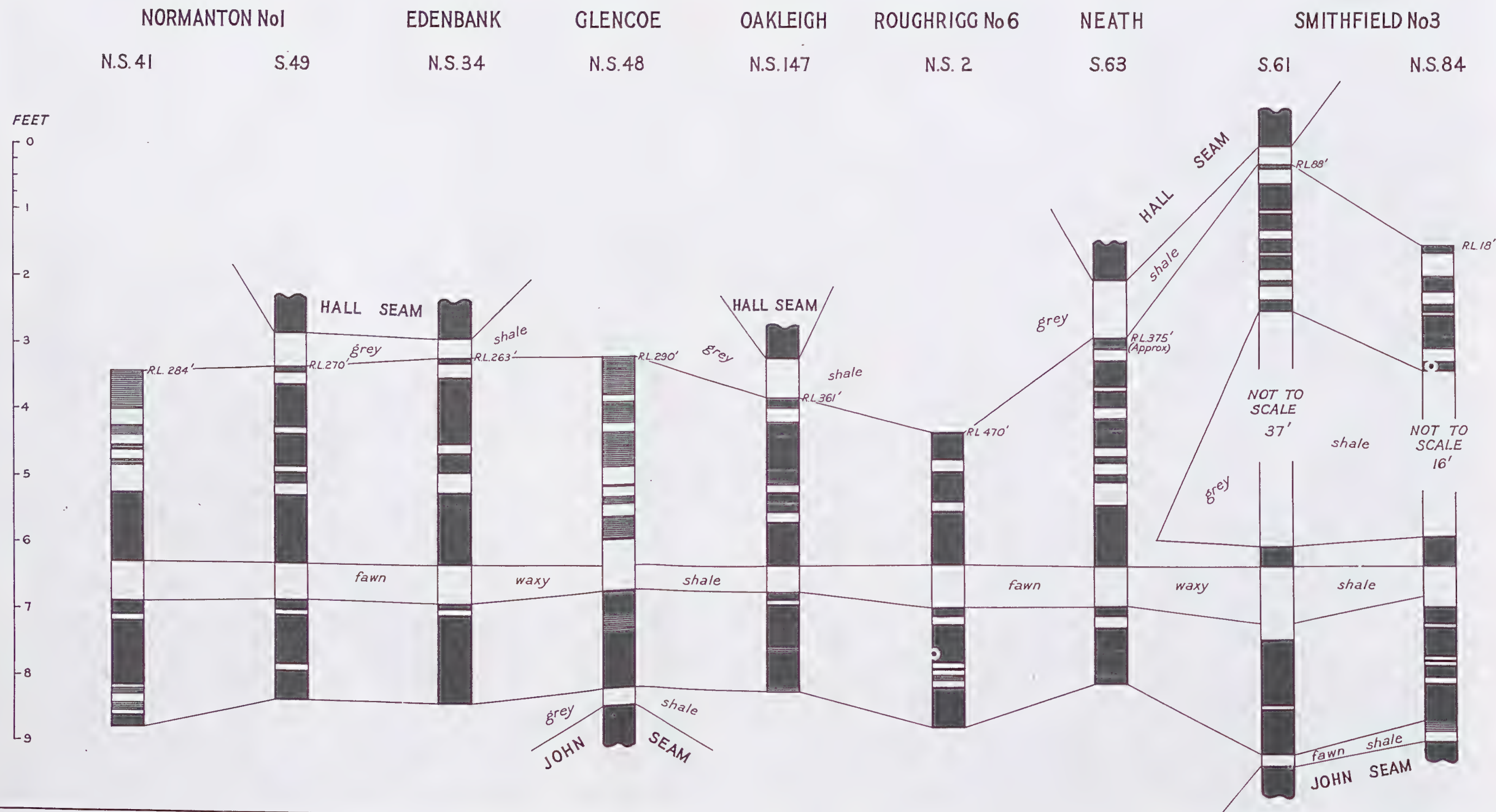




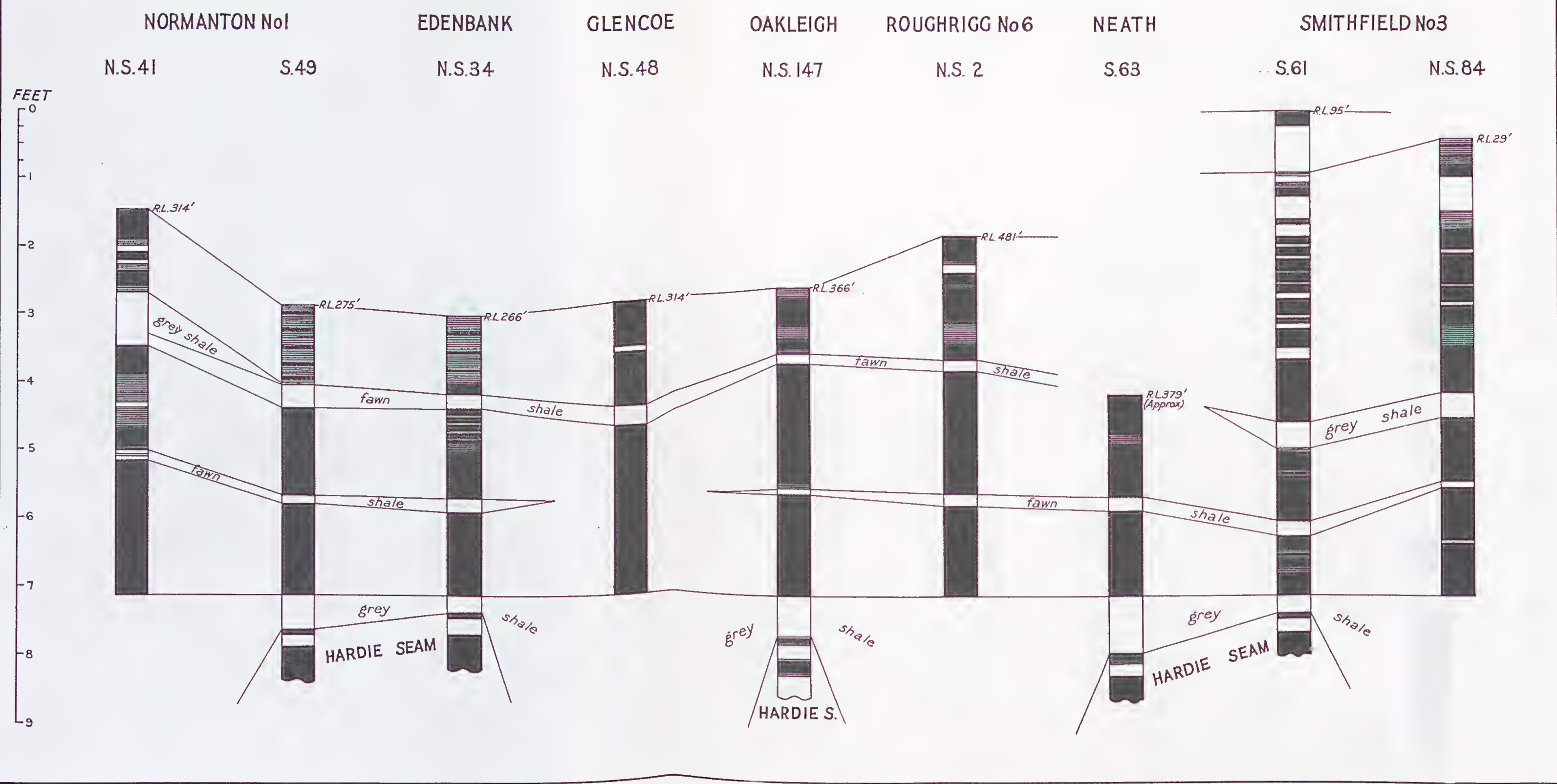




FIG.21

FIG.21

ROSEWOOD WALLOON COALFIELD  
WALLOON COAL MEASURES      HALL SEAM





Although areas of workable coal were established by the exploration programme in some parts of the coalfield, these are now depleted except for a small tonnage of potential open cut coal in the vicinity of Mount Elliott No. 1 Extended Colliery in the Amberley district.

### JOHN SEAM

In 1910 at Glencoe No. 1 Colliery John Potts was the first to exploit the 5 foot seam of coal which throughout the coalfield lies above the Gunthorpe seam at intervals ranging from a few inches to nearly 60 feet. To this coal the name John seam is now applied, the name Potts having already been used for one of the seams in the Collinsville Coal Measures of the Bowen Coalfield (Reid, 1929).

The John seam has been worked at the following collieries:—

*Abandoned*—Glencoe No. 1, Glencoe No. 5, Glencoe No. 6, Glencoe Extended, Lanefield Extended No. 3, Oakleigh No. 1, Perry's Nob No. 1, Smithfield No. 2, Smithfield No. 3, Westvale No. 2 (previously Perry's Nob No. 2).

*Working*—Normanton No. 1. At this colliery mining operations in the John seam ceased in 1960, but the Joynson seam is still being worked.

The John seam is generally about 5 feet thick and includes several thin shale beds only one of which is persistent and characteristic. This is a 3 to 6 inch bed of fawn waxy shale lying from 1 to 2 feet from the floor (see fig. 19).

The John seam is now of no economic significance, its last exploitation being at Smithfield No. 3 Colliery where it was worked in conjunction with either the upper members of the underlying Gunthorpe seam or the bottom coal section of the overlying Hardie seam.

### HARDIE SEAM

Generally no more than 10 feet above the John seam there occurs a 4 to 5 foot seam of coal which is here named the Hardie seam. This coal was first worked in 1920 by J. Hardie at Edenbank Colliery along with the immediately overlying Hall seam.

The Hardie seam has been worked at the following collieries:—

*Abandoned*—Edenbank, Lanefield Extended No. 3, Neath No. 1, Neath No. 2 (previously Alngarth and Mason's Top Tunnel), Smithfield No. 2, Smithfield No. 3.

*Working*—Normanton No. 1. At this colliery mining operations in the Hardie seam ceased in 1927, but the Joynson seam is still being worked.

Throughout the coalfield the Hardie seam displays a section almost identical with that of the John seam; it is 5 feet thick and is characterized by a persistent bed of fawn waxy shale up to 10 inches thick,

lying from 1 to 2 feet from the floor (see fig. 20). The two seams can be distinguished with certainty only by their stratigraphic position although an aid to identification is the greater proportion of thin shale beds in the Hardie seam and the extra thickness of its fawn waxy shale marker. In addition, splitting is evident only in the Hardie seam; in the Smithfield No. 3 mine area the thick grey shale interbed lies about 2 feet from the roof and is as much as 37 feet thick.

The Hardie seam has never been exploited by itself to any extent, but only in conjunction with the underlying John and overlying Hall seams where the thickness of the intervening strata permitted. As shown by the drilling programme the Hardie seam is of no economic interest.

### HALL SEAM

The name Hall seam is here applied to the 4 to 5 foot seam of coal which was first worked in 1905 by J. F. Hall at Glencoe No. 1 Colliery. This coal lies above the Hardie seam at intervals ranging from a few inches to 20 feet.

The Hall seam has been worked at the following collieries:—

*Abandoned*—Edenbank, Glencoe No. 1, Glencoe No. 2, Glencoe No. 3, Glencoe No. 4, Glencoe No. 6, Lanefield Extended No. 3, Neath No. 1, Neath No. 2, Perry's Nob No. 1, Perry's Nnob No. 2, Roughrigg No. 1, Roughrigg No. 6, Smithfield No. 3.

*Working*—Normanton No. 1. At this colliery mining operations in the Hall seam ceased in 1935, but the Joynson seam is still being worked.

The Hall seam is generally 4 to 5 feet thick and includes two persistent beds of fawn shale each 1 to 3 inches thick lying approximately 1 foot 6 inches and 3 feet from the floor (see fig. 21). In places a lenticular bed of dark grey and grey shale up to 7 inches thick occurs immediately above the upper fawn shale bed. Whereas the bottom 3 feet of the seam consist of good quality coal, the top 1 to 2 feet usually contain a high proportion of thin beds of carbonaceous and fawn shale.

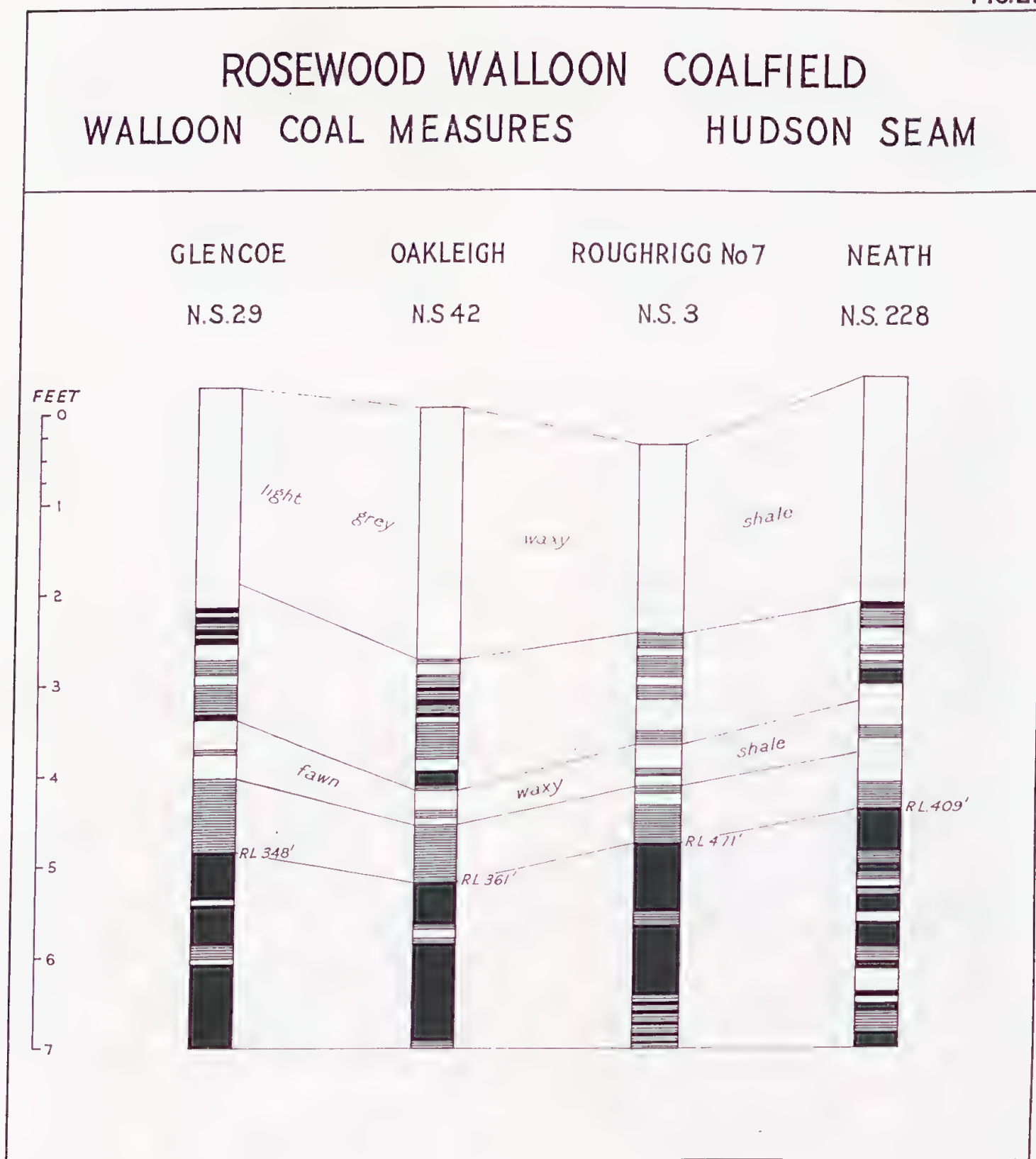
The Hall seam has been worked extensively in the area around Perry's Knob and in the Ebenezer district, but no reserves of coal were established in this seam by the drilling programme.

### HUDSON SEAM

In the Perry's Knob area a thin coal seam 2 to 3 feet thick lies from 8 to 16 feet above the Hall seam, the intervening strata being interbedded carbonaceous and fawn shale. This coal was first discovered in 1902 by Joseph Hudson while sinking a well in Portion 406, Parish of Walloon and so the name Hudson seam is applied.



FIG.22



Of the eighteen named seams in the Walloon Coal Measures, the Hudson seam is the only one which has not been worked.

The Hudson seam, which is 2 to 3 feet thick and includes several thin beds of carbonaceous and fawn shale (see fig. 22), possesses no distinct lithological character, but is readily identified by its stratigraphic associations. It is separated by up to 16 feet of interbedded carbonaceous and fawn shale from the underlying Hall seam and is overlain by as much as 16 feet of

similar strata containing two prominent beds of fawn, waxy shale each about 2 feet thick. These marker beds lie 2 to 3 feet and 8 to 15 feet respectively above the roof of the Hudson seam. This sequence of carbonaceous shale, fawn shale, and coal overlying the Hall seam is in turn overlain by at least 150 feet of massive sandstone. This upper sandstone has a disconformable base which in places rests almost directly on the Hall seam; the maximum erosional relief observed at its contact with the coal-bearing beds is approximately 20 feet.



## STRUCTURAL GEOLOGY

The Rosewood-Walloon Coalfield is situated in the north-western part of the Moreton Basin in an area which has been subjected to only minor earth movements. In consequence, the geological structure is very simple. The coal-bearing beds dip gently at angles rarely exceeding  $3^{\circ}$  and dislocations which invariably take the form of normal faults are generally not severe, the maximum displacement observed being about 100 feet.

### FOLDING

In the Rosewood district the regional dip of the Walloon Coal Measures is 2 to  $3^{\circ}$  in a general south-easterly direction. Towards the east, however, the dip gradually changes, first to the south, then to the south-west in the vicinity of the township of Walloon and finally to an almost westerly direction in the Loamside and Hampstead areas. This change in the attitude of the coal-bearing beds is due to the influence of the zone of steeply dipping Mesozoic strata occurring to the west of Ipswich which was first mentioned by Cameron (1907) and later termed the West Ipswich disturbance by Denmead (1955) and the West Moreton disturbance by Hill (1961). The resultant shallow syncline produced in the Jurassic rocks in the area between Calvert and Hampstead plunges gently to the south and so plays an important part in controlling the distribution of the coal-bearing beds of the Walloon Coal Measures, not only in the coalfield but throughout the whole of the West Moreton district.

Along the western limb of the syncline and its northern closure where most of the collieries, working and abandoned, are situated, the dip of the beds rarely exceeds  $3^{\circ}$ . Local irregularities in grade are common and in places give rise to reversals of dip. Where modern coal handling systems have not yet been introduced these "swallows", as they are termed in the local mining industry, considerably hamper underground coal transport; everywhere, they create problems in mine drainage. Along the eastern limb of the syncline where the Walloon Coal Measures have been affected by the West Ipswich disturbance, coal seams dipping as much as  $14^{\circ}$  have been worked. Coal mining operations in this part of the coalfield, however, were not extensive.

### FAULTING

Because of the paucity of outcrop in the Walloon Coal Measures faulting cannot usually be detected by surface observations. Hence only those faults have been mapped which have been exposed in mine workings or the positions of which have been established from drillhole data. These dislocations are invariably normal faults and trend generally in a north-westerly direction more or less parallel to the regional trend of the West Ipswich disturbance. Major faults of this type occur in the Westvale No. 5, Lanefield No. 5, Rosemount No. 4, Roughrigg No. 5, Malabar, Caledonian No. 3, New Amberfield, Mount Elliott No. 1 Extended and Noblevale No. 7 mine areas, the displacements varying from 20 to 100 feet.

Of the known major faults the only one which does not conform to the pattern described above occurs in the New Mountain View No. 3 and United No. 7 mine areas. This fault is of the normal type, but trends in a westerly direction. It has been traced in the subsurface for a distance of almost 1 mile. It apparently dies out to the east in the Roughrigg No. 7 mine area, but its behaviour to the west is not known. None of the other major faults in the coalfield has been proved to extend laterally for more than 60 chains.

A second set of normal faults trend in a general north-easterly direction. Such dislocations have been mapped in Oakleigh No. 3, Normanton No. 2, Lanefield Extended No. 3, and New Amberfield Collieries. These are usually minor faults with displacements of no more than 10 feet, but the fault at Normanton No. 2 Colliery appears to be an exception; its displacement is not known, but it was sufficient to prevent further mine development.

In Caledonian No. 5 Colliery igneous dykes of basaltic composition have been intruded along minor normal faults which trend north-westerly. In the western part of the colliery the Wass seam has been seriously affected by the intrusion of a basaltic sill which most likely emanated from a parallel line of structural weakness. Within the coalfield the only other recorded occurrence of igneous intrusion in the Walloon Coal Measures is in the New Amberfield mine area; in drillhole N.S. 74 a basaltic sill has intruded a seam of coal lying approximately 20 feet below the Wass seam.



## COAL RESOURCES

### PRODUCTION AND UTILIZATION

Commercial coal production in the Rosewood-Walloon Coalfield commenced in 1881 with the opening of Old Walloon Colliery in Portion 31, Parish of Walloon, about 50 chains north-east of Walloon Railway Station. With the exception of the year 1904, annual production figures are not available for the

period 1881 to 1913 as the tonnages were then recorded along with those from Ipswich and Darling Downs. However, it is estimated that the total coal produced in the Rosewood-Walloon Coalfield during that period would not have exceeded 1 million tons. Annual production for the years 1904 and 1914 to 1969 is listed in table IV and shown graphically in fig. 23.

FIG. 23

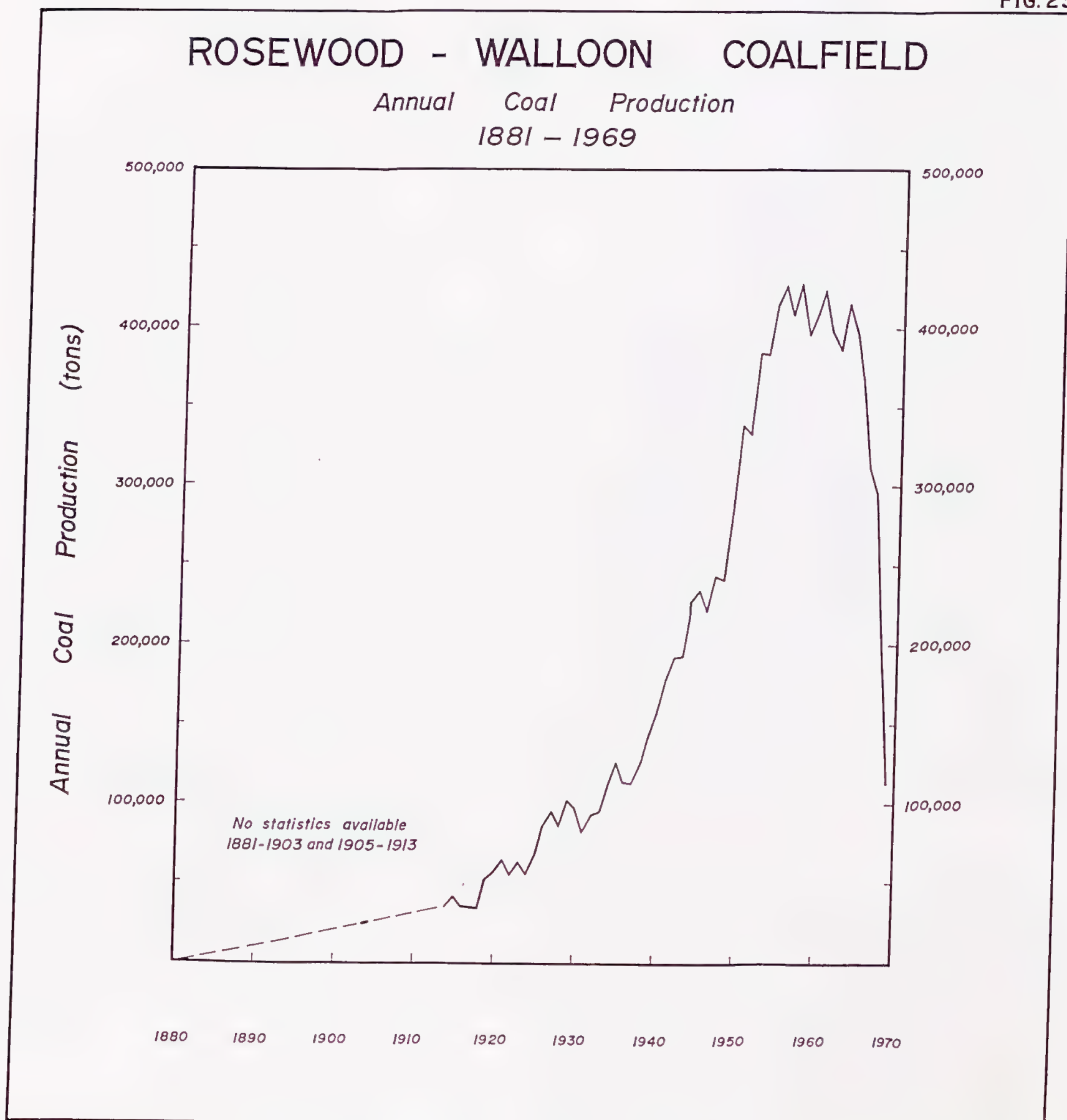




TABLE IV

ANNUAL COAL PRODUCTION—ROSEWOOD-WALLOON COALFIELD

| Year            | Tons          | Year       | Tons    |
|-----------------|---------------|------------|---------|
| 1881 to 1903 .. | not available | 1941 .. .. | 178,012 |
| 1904 .. ..      | 25,706        | 1942 .. .. | 191,740 |
| 1905 to 1913 .. | not available | 1943 .. .. | 193,112 |
| 1914 .. ..      | 35,666        | 1944 .. .. | 226,746 |
| 1915 .. ..      | 41,216        | 1945 .. .. | 234,508 |
| 1916 .. ..      | 35,563        | 1946 .. .. | 223,180 |
| 1917 .. ..      | 35,090        | 1947 .. .. | 243,104 |
| 1918 .. ..      | 34,601        | 1948 .. .. | 241,169 |
| 1919 .. ..      | 52,563        | 1949 .. .. | 287,019 |
| 1920 .. ..      | 56,136        | 1950 .. .. | 338,522 |
| 1921 .. ..      | 64,660        | 1951 .. .. | 334,288 |
| 1922 .. ..      | 56,032        | 1952 .. .. | 384,465 |
| 1923 .. ..      | 63,396        | 1953 .. .. | 383,468 |
| 1924 .. ..      | 56,353        | 1954 .. .. | 414,294 |
| 1925 .. ..      | 67,292        | 1955 .. .. | 425,773 |
| 1926 .. ..      | 86,528        | 1956 .. .. | 408,956 |
| 1927 .. ..      | 95,095        | 1957 .. .. | 427,960 |
| 1928 .. ..      | 86,433        | 1958 .. .. | 396,267 |
| 1929 .. ..      | 101,282       | 1959 .. .. | 408,389 |
| 1930 .. ..      | 98,135        | 1960 .. .. | 423,894 |
| 1931 .. ..      | 84,180        | 1961 .. .. | 398,542 |
| 1932 .. ..      | 94,060        | 1962 .. .. | 388,248 |
| 1933 .. ..      | 95,357        | 1963 .. .. | 415,478 |
| 1934 .. ..      | 111,368       | 1964 .. .. | 399,448 |
| 1935 .. ..      | 123,939       | 1965 .. .. | 369,122 |
| 1936 .. ..      | 114,289       | 1966 .. .. | 312,125 |
| 1937 .. ..      | 113,297       | 1967 .. .. | 297,219 |
| 1938 .. ..      | 125,836       | 1968 .. .. | 192,043 |
| 1939 .. ..      | 143,663       | 1969 .. .. | 113,236 |
| 1940 .. ..      | 158,085       |            |         |

Coal production reached its peak in the period 1954 to 1963 when over 4.1 million tons of coal were produced. Each year since then, however, output has fallen appreciably, from 415,478 tons in 1963 to 113,236 tons in 1969. The utilization by various consumers of coal produced from the Rosewood-Walloon Coalfield in the years 1963 and 1969 is shown in table V.

TABLE V  
UTILIZATION OF COAL PRODUCED FROM THE ROSEWOOD-WALLOON COALFIELD

| Consumer            | 1963    | 1969    |
|---------------------|---------|---------|
|                     | Tons    | Tons    |
| Electricity .. ..   | 142,100 | 36,873  |
| Gas .. ..           | 116,200 | 34,083  |
| Railways .. ..      | 106,400 | 4,900   |
| Miscellaneous .. .. | 60,778  | 37,380  |
| Total .. ..         | 415,478 | 113,236 |

Statistics supplied by Queensland Coal Board.

The sharp decline in production in this 6 year period is the result of decreased consumption by all three major consumers arising from such factors as the siting of new power stations (Swanbank A) on the Ipswich Coalfield, the use of petroleum products and natural gas in town gas supply, and the dieselization of the railways. With the commissioning of the first stages of Swanbank B power station in 1970, the situation as far as the Rosewood-Walloon Coalfield is concerned is likely to deteriorate further. Within the next few years closure of most of the six collieries now operating seems inevitable.

## ANALYSES

During the Departmental programme of coal exploration in the Rosewood-Walloon Coalfield in the years 1951 to 1961, a total of 525 samples of coal were analysed at the Government Chemical Laboratory, the main determinations being proximate analysis, calorific value, sulphur, and specific gravity.

The sampling of these sections which were obtained from diamond drillholes and mine workings was designed to assess as accurately as possible the quality of the product that could be marketed after handpicking of stone both underground and on the surface, the only form of beneficiation that was then widely employed. Maximum ash acceptable at that time was 25 per cent. A typical analysis is as follows:—

Seam—Wass.

Location—Drillhole N.S. 77, United No. 8 mine area.

| Proximate Analysis—     | Per cent.          |
|-------------------------|--------------------|
| Moisture at 105°C .. .. | 3.9                |
| Volatile Matter .. ..   | 37.7               |
| Fixed Carbon .. ..      | 35.4               |
| Ash .. ..               | 23.0               |
| Calorific Value .. ..   | 10,560 BTU per lb. |
| Sulphur .. ..           | 0.63 per cent.     |
| Specific Gravity .. ..  | 1.41               |

At a later date a jig washery was installed at United No. 8 Colliery. To reproduce as closely as possible that form of beneficiation, the above sample was washed in a medium of specific gravity of 1.6 and the floats amounting to 78.4 per cent by weight were analysed with the following results:—

| Proximate Analysis—     | Per cent.          |
|-------------------------|--------------------|
| Moisture at 105°C .. .. | 5.2                |
| Volatile Matter .. ..   | 38.2               |
| Fixed Carbon .. ..      | 41.9               |
| Ash .. ..               | 14.7               |
| Calorific Value .. ..   | 11,550 BTU per lb. |
| Sulphur .. ..           | 0.63 per cent.     |
| Specific Gravity .. ..  | 1.35               |

Maximum ash acceptable for washed coal is now 18 per cent.

As shown by these analyses a characteristic feature of coal from the Walloon Coal Measures is its high content of volatile matter. With this is to be correlated its very good performance as a gas coal.

The two parameters used in the ASTM classification of coal, dry mineral-matter-free fixed carbon and moist mineral-matter-free calorific value, have been calculated using the Parr formulae for all of the 525 coal analyses carried out during the drilling programme. These data show that the coal from the Walloon Coal Measures occurs in the range High Volatile A to High Volatile B Bituminous coal. D.M.M.F. fixed carbon varies from 44.5 to 56.7 per cent. and M.M.M.F. calorific value from 13,060 to 14,700 BTU per lb.



TABLE VI  
ROSEWOOD-WALLOON COALFIELD  
Virgin Coal Reserves established by Department of Mines

| Mine Area                                 |     | Seam                                    |                   | Original Reserves<br>established 1952 to 1961 |                               | Remaining Reserves<br>as at 1st March, 1969 |                     | Remarks                                                            | References                                             |
|-------------------------------------------|-----|-----------------------------------------|-------------------|-----------------------------------------------|-------------------------------|---------------------------------------------|---------------------|--------------------------------------------------------------------|--------------------------------------------------------|
|                                           |     |                                         |                   | Indicated<br>(tons)                           | Measured<br>(tons)            | Measured<br>(tons)                          | Indicated<br>(tons) |                                                                    |                                                        |
| Roughrigg No. 7                           | (A) | Trewick-<br>Gunthorpe<br>Gunthorpe      |                   |                                               | 89,000                        | 89,000                                      |                     | east of fault                                                      | Hawthorne, 1954b                                       |
|                                           |     |                                         |                   |                                               | 411,000                       | 200,000                                     |                     | west of fault                                                      |                                                        |
| New Malabar No. 1                         | (A) | Joynson                                 |                   | 365,000                                       |                               |                                             | 365,000             |                                                                    | Hawthorne, 1954a<br>Cameron, 1963h                     |
| Lanefield No. 5                           | (A) | Butler<br>Wass                          |                   |                                               | 100,000<br>920,000            | Nil<br>859,000                              |                     |                                                                    | Cameron, 1956<br>Chiu Chong, 1962                      |
| Normanton No. 1                           | (O) | John<br>Gunthorpe<br>Trewick<br>Joynson | (C)<br>(C)<br>(C) |                                               | 65,000                        | 65,000                                      |                     | north<br>south                                                     | Cameron, 1959                                          |
|                                           |     |                                         |                   |                                               | 240,000                       | 240,000                                     |                     |                                                                    |                                                        |
|                                           |     |                                         |                   |                                               | 400,000                       | 343,000                                     |                     |                                                                    |                                                        |
|                                           |     |                                         |                   |                                               | 600,000                       | 307,000                                     |                     |                                                                    |                                                        |
|                                           |     |                                         |                   |                                               | 150,000                       | 150,000                                     |                     |                                                                    |                                                        |
| Glencoe Extd<br>&<br>Glencoe Extd No. 1   | (A) | Gunthorpe                               |                   |                                               | 67,000                        | Nil                                         |                     | north<br>south<br>tops and bottoms<br>of seam<br>tops of seam only | Cameron, 1961a                                         |
|                                           | (O) | Joynson                                 | (C)               |                                               | 165,000                       | Nil                                         |                     |                                                                    |                                                        |
|                                           |     |                                         |                   |                                               | 150,000                       | 150,000                                     |                     |                                                                    |                                                        |
|                                           |     | Butler                                  |                   |                                               | 430,000                       | 166,000                                     |                     |                                                                    |                                                        |
| Oakleigh No. 3<br>&<br>Oakleigh No. 4     | (A) | Joynson                                 |                   |                                               | 115,000                       | Nil                                         |                     |                                                                    | Cameron, 1961c<br>Chiu Chong, (1961)<br>Cameron, 1962d |
|                                           | (O) | Butler<br>Cowell<br>Wass                | (C)<br>(V)        |                                               | 505,000                       | 232,000                                     |                     |                                                                    |                                                        |
|                                           |     |                                         |                   |                                               | 275,000                       | 275,000                                     |                     |                                                                    |                                                        |
|                                           |     |                                         |                   |                                               | 180,000                       | 180,000                                     |                     |                                                                    |                                                        |
| United No. 8                              | (O) | Cowell<br>Wass<br>Haenke                | (C)<br>(V)        |                                               | 790,000                       | 474,000                                     |                     |                                                                    | Cameron, 1962a                                         |
|                                           |     |                                         |                   |                                               | 695,000                       | 395,000                                     |                     |                                                                    |                                                        |
|                                           |     |                                         |                   |                                               | 470,000                       | 470,000                                     |                     |                                                                    |                                                        |
| Mount Elliott No. 1<br>Extd               | (O) | Little Jim<br>Boughen<br>Cowell<br>Wass | (C)<br>(V)<br>(V) |                                               | 545,000                       | 380,000                                     |                     |                                                                    | Cameron, 1963c<br>Cameron, 1963d                       |
|                                           |     |                                         |                   |                                               | 265,000                       | 166,000                                     |                     |                                                                    |                                                        |
|                                           |     |                                         |                   |                                               | 1,080,000                     | 1,080,000                                   |                     |                                                                    |                                                        |
|                                           |     |                                         |                   |                                               | 670,000                       | 670,000                                     |                     |                                                                    |                                                        |
| Smithfield No. 3                          | (A) | John-Hardie<br>Gunthorpe                |                   |                                               | 330,000<br>120,000            | 140,000<br>120,000                          |                     |                                                                    | Cameron, 1962b                                         |
| New Mountain View<br>No. 3                | (A) | Haenke                                  |                   |                                               | 70,000<br>280,000             | 70,000<br>205,000                           |                     | north of fault<br>south of fault                                   | Cameron, 1963a                                         |
| United No. 7                              | (A) | Haenke-Wass                             |                   |                                               | 157,000<br>218,000            | 52,000<br>218,000                           |                     | north of fault<br>south of fault                                   | Cameron, 1963b                                         |
| Rosewood No. 2                            | (O) | Joynson                                 |                   |                                               | 490,000                       | 243,000                                     |                     |                                                                    | Cameron, 1963g                                         |
| Rosemount No. 4                           | (A) | Joynson<br><br>Butler                   |                   |                                               | 90,000                        | 90,000                                      |                     | north<br>south<br>north<br>south                                   | Cameron, 1962c                                         |
|                                           |     |                                         |                   |                                               | 120,000                       | 120,000                                     |                     |                                                                    |                                                        |
|                                           |     |                                         |                   |                                               | 350,000                       | 239,000                                     |                     |                                                                    |                                                        |
|                                           |     |                                         |                   |                                               | 330,000                       | 245,000                                     |                     |                                                                    |                                                        |
| Westvale No. 5                            | (A) | Wass                                    |                   |                                               | 135,000                       | 120,000                                     |                     |                                                                    | Cameron, 1961b                                         |
| Caledonian No. 5<br>&<br>Caledonian No. 6 | (A) | Butler                                  |                   |                                               | 408,000                       | 408,000                                     |                     |                                                                    | Chiu Chong, 1963c                                      |
|                                           | (A) | Wass<br>Wass                            |                   |                                               | 239,000<br>980,000            | 52,000<br>929,000                           |                     |                                                                    |                                                        |
| Roughrigg No. 5                           | (A) | Cowell<br>Wass<br>Haenke-Wass           |                   | 60,000                                        | 250,000<br>260,000<br>600,000 | 250,000<br>260,000<br>457,000               | 60,000              |                                                                    | Chiu Chong, 1963c                                      |
|                                           |     | Total                                   |                   | 425,000                                       | 15,044,000                    | 11,282,000                                  | 425,000             |                                                                    |                                                        |

(A) denotes abandoned colliery.

(O) denotes operating colliery.

(C) denotes workings ceased in that seam but colliery still operating.

(V) denotes seam not yet worked.



TABLE VII  
ROSEWOOD-WALLOON COALFIELD  
Revised Virgin Coal Reserves as at 1st March, 1969

| Colliery                 | Measured Reserves<br>classified according to seams<br>(tons) | Total Measured<br>Reserves<br>of Mine Area<br>(tons) | Remarks                                                                                     |
|--------------------------|--------------------------------------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Normanton No. 1          | *Joynson (north) 307,000<br>(south) 218,000                  | 307,000                                              | Total excludes southern reserves which would be best exploited from Rosewood No. 2 Colliery |
| Glencoe Extd No. 1       | *Butler 339,000                                              | 473,000                                              | Total includes reserves of Rosemount No. 4 mine area                                        |
| Oakleigh No. 4           | *Cowell 275,000<br>Wass 180,000                              | 455,000                                              |                                                                                             |
| United No. 8             | *Wass 395,000<br>Haenke 470,000                              | 865,000                                              |                                                                                             |
| Mount Elliott No. 1 Extd | *Boughen 166,000<br>Cowell 1,080,000<br>Wass 670,000         | 1,916,000                                            |                                                                                             |
| Rosewood No. 2           | *Joynson 243,000                                             | 461,000                                              | Total includes southern reserves of Normanton No. 1 mine area                               |
|                          |                                                              | 4,477,000                                            | Sub-total for operating mine areas                                                          |
| Lanefield No. 5          | Wass 786,000                                                 | 786,000                                              |                                                                                             |
| Rosemount No. 4          | Butler 134,000                                               |                                                      | Total excludes reserves which would be best exploited from Glencoe Extd No. 1 Colliery      |
| Caledonian No. 6         | Wass 681,000                                                 | 681,000                                              |                                                                                             |
|                          |                                                              | 1,467,000                                            | Sub-total for abandoned mine areas                                                          |
|                          |                                                              | 5,944,000                                            | TOTAL                                                                                       |

\* Denotes present working seam.

A typical ultimate analysis of coal from the Walloon Coal Measures (dry mineral-matter-free basis) has been recorded by the Queensland Coal Board (1968, p. 17) as follows:—

|                | Per cent. |
|----------------|-----------|
| Carbon .. ..   | 80.7      |
| Hydrogen .. .. | 6.3       |
| Nitrogen .. .. | 1.7       |
| Oxygen .. ..   | 11.3      |

In terms of Seyler's classification the coal is perhydrous. With its high hydrogen content can be related the high yield of tar on carbonization, 12 to 13 gallons per ton at 900°C (CSIRO, 1967, table 1). In 1942 samples of coal from the Butler seam at Lane-field No. 3 Colliery yielded from 45 to 56 gallons per ton of heavy oil on carbonization at 600°C at the Government Chemical Laboratory.

### RESERVES

In appraising seam sections cored by diamond drilling in the Rosewood-Walloon Coalfield, the following criteria of workability were employed:—a minimum thickness of 3 feet; a workable coal to stone ratio; and an ash content, after exclusion of stone

bands normally removed in practice, of not more than 25 per cent. Although these criteria were established before the installation of washing plants, it has been demonstrated that sections which were workable under the old conditions could also be economically worked and washed to give coal with not more than 18 per cent. ash.

The status of the reserves established by the drilling programme depends on the distance between observation points (diamond drillholes or mine workings)—

- (a) measured reserves—up to 12½ chains
- (b) indicated reserves—from 12½ to 20 chains.

The area of both measured and indicated reserves is defined as extending no more than 5 chains beyond the most outlying of those points of observation at which the seam section satisfies the three requirements of workability.

These definitions of measured and indicated reserves are in conformity with those recently set out by the Department of Mines, Queensland (1968).

In the years 1952 to 1961, measured reserves totalling 15.0 million tons and indicated reserves totalling 0.4 million tons were established by Departmental diamond drilling in the coalfield. Since the



assessment of these reserves, a large proportion of the coal has been extracted. Measured and indicated reserves now remaining total 11·1 million and 0·4 million tons respectively. A summary of the original and remaining virgin coal reserves established by Departmental drilling is given in Table VI.

As indicated in Table VI, operations have been abandoned in ten of the mine areas tested and certain of the seams in collieries still operating are no longer being worked. Remaining measured and indicated reserves left unexploited in this manner total 6·8 million and 0·4 million tons respectively. While most

of this tonnage should be disregarded in a current appraisal of the virgin coal reserves of the field, there are several individual deposits which because of their size or location are still of economic interest. These particular reserves in the abandoned mine areas are listed in table VII, together with those reserves which remain to be exploited in mine areas still operating.

Total measured reserves of virgin coal in the coalfield are 5·9 million tons. In the light of expected demand for Rosewood-Walloon coal, this figure is considered adequate.

31st December, 1969.

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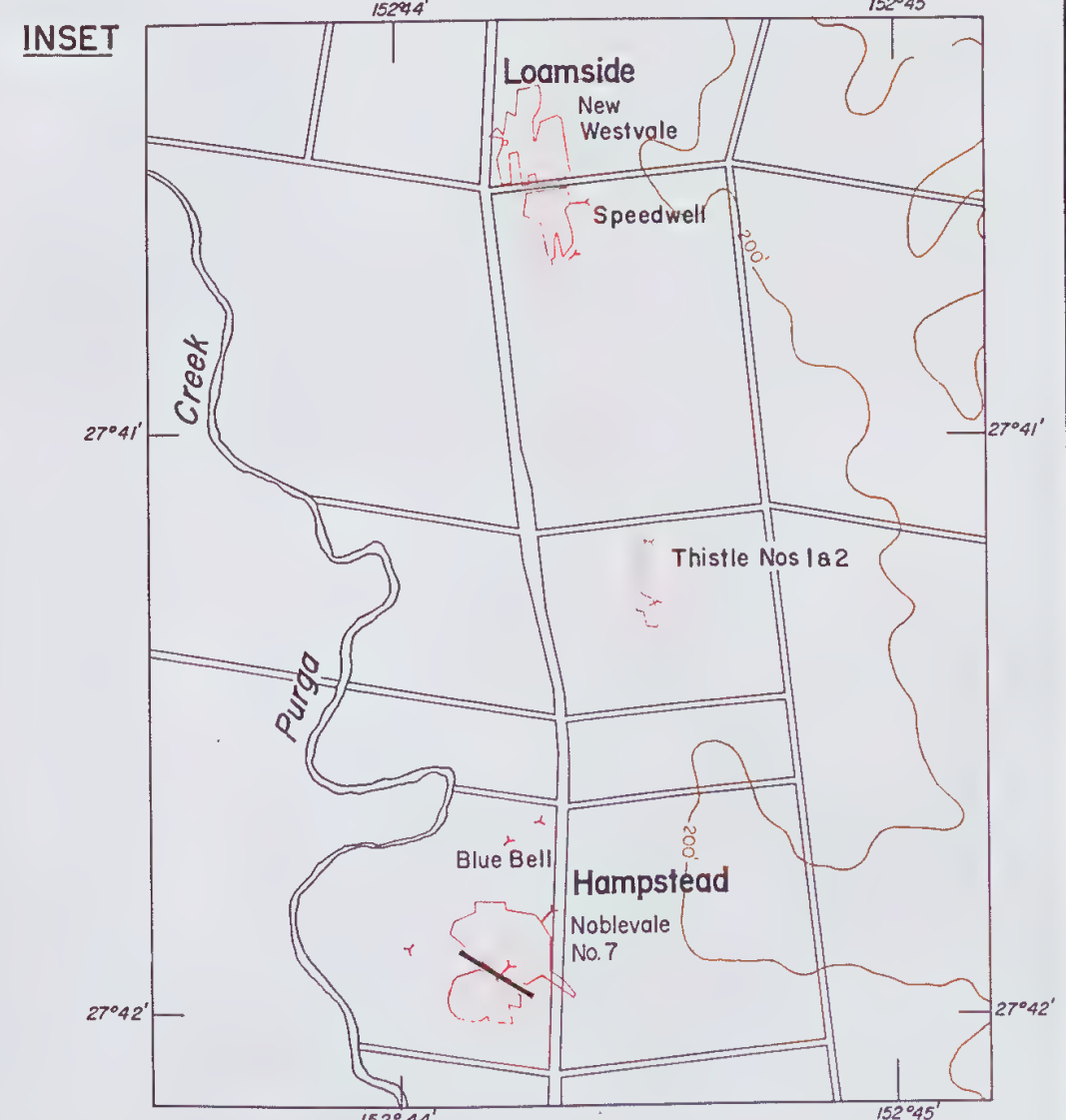
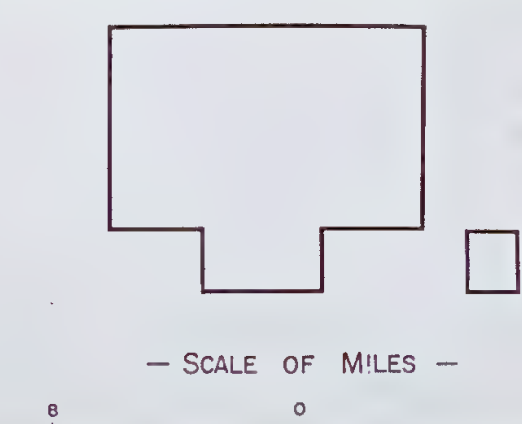
ROSEWOOD WALLOON COALFIELD

Plan Showing  
Adits & Limits of Colliery Workings  
Contours (200 ft interval)  
Location of Measured Sections  
Outcrop of Seams projected from  
subsurface data showing faults.

Colliery Workings @ S.21; Drillholes @ N.S. 147  
Wass seam

— SCALE OF CHAINS —  
0 40 80

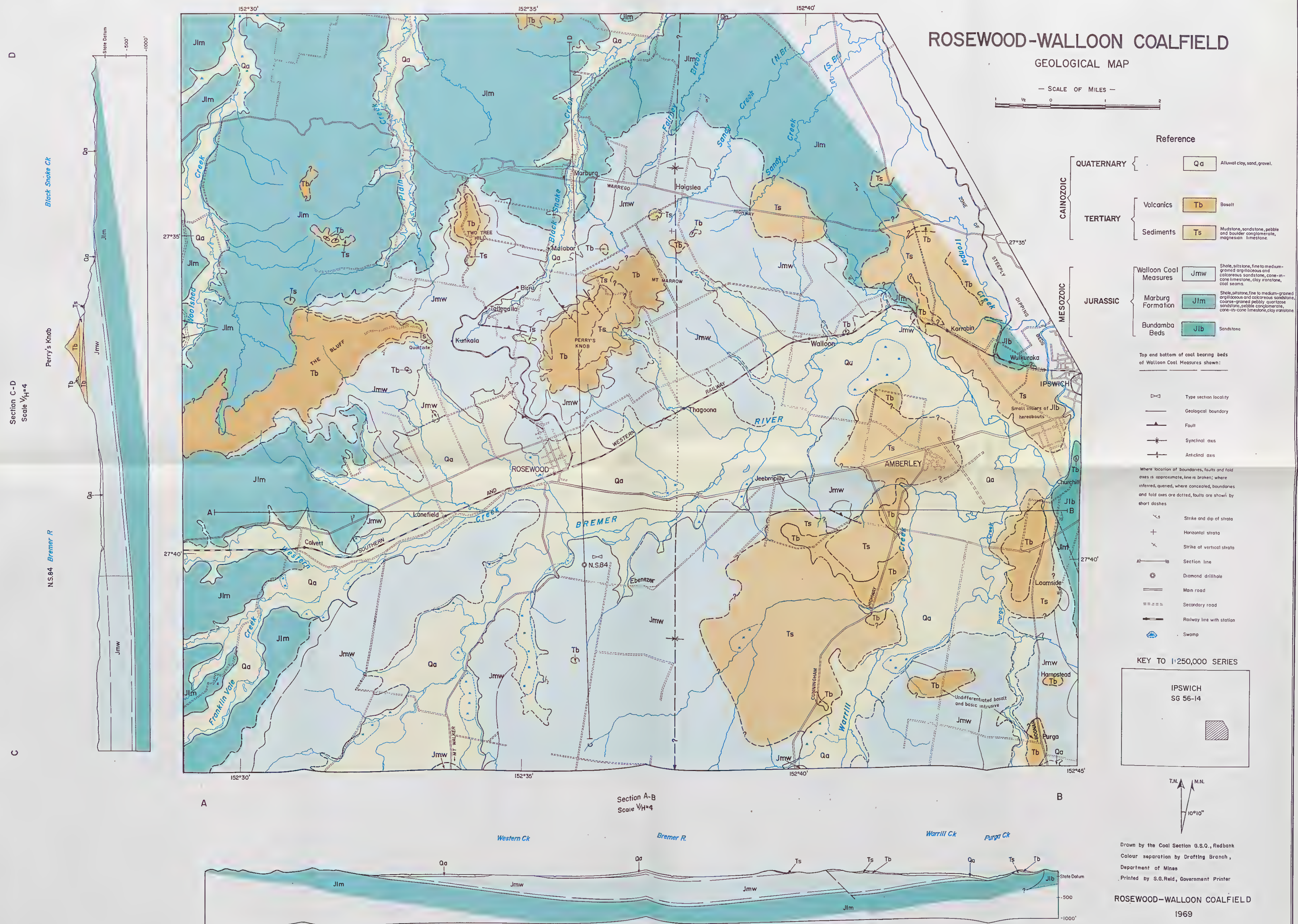
Key to Location of Main Plan and Inset









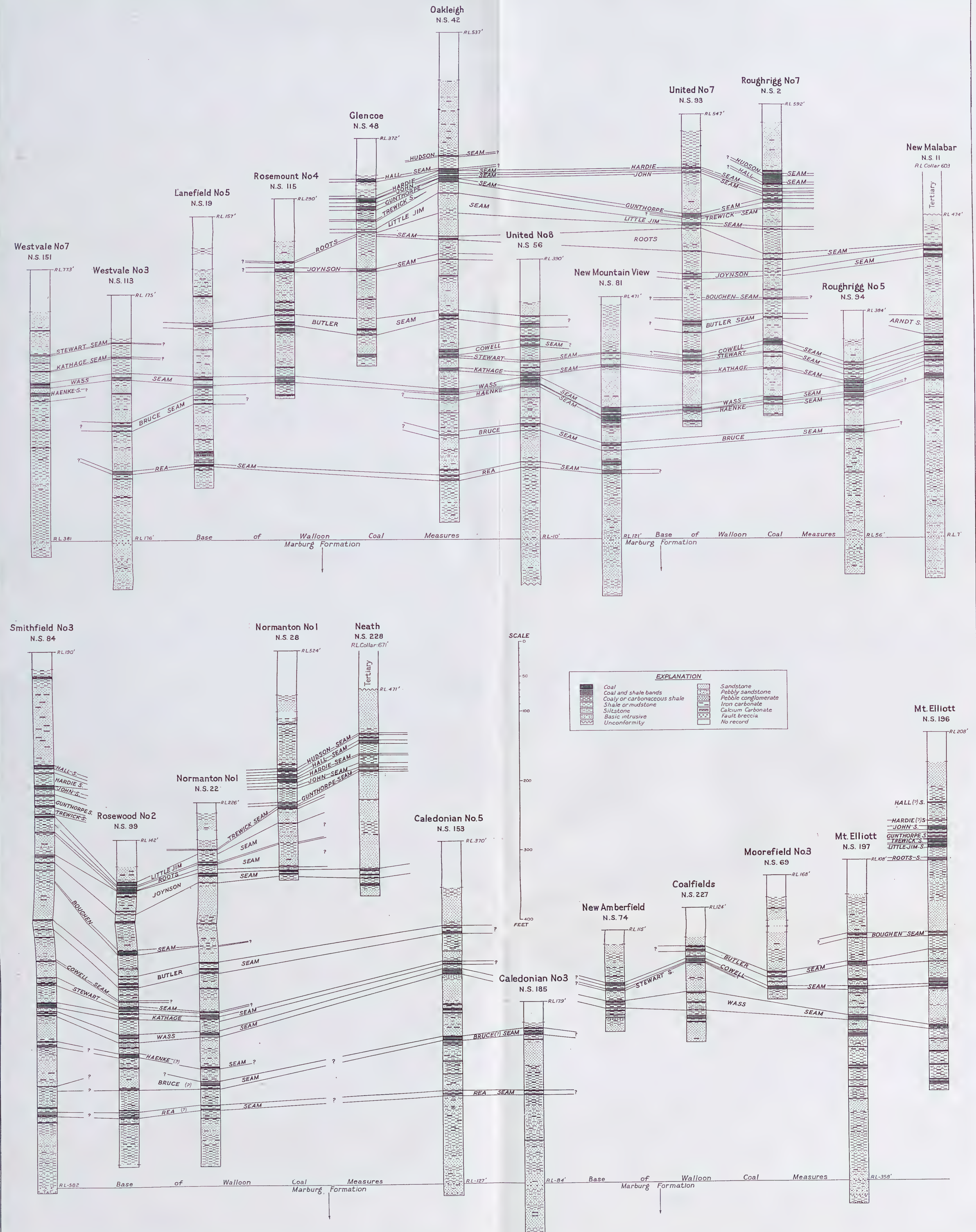








ROSEWOOD - WALLOON COALFIELD  
STRATIGRAPHIC SECTIONS WALLOON COAL MEASURES

















QUEENSLAND  
DEPARTMENT OF MINES



GEOLOGICAL SURVEY OF QUEENSLAND  
(J. T. Woods, Chief Government Geologist)

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# THE FAUNA OF THE MARYBOROUGH FORMATION, SOUTH-EAST QUEENSLAND

by P. J. G. FLEMING

Geological Survey of Queensland

## ABSTRACT

The fauna of the Lower Cretaceous marine Maryborough Formation is determined and listed. Twelve species are figured, and full descriptions are given for nine which have not previously been described adequately. No new species are named, but *Rotularia?* sp., *Pseudavicula* sp., *Meleagrinnella* sp., and *Camptochlamys* sp. are recorded for the first time from these rocks, and the occurrence of *Fissilunula clarkei* (Moore, 1870) is confirmed. The stratigraphy is summarized, indicating the probable thickening of the formation east of Maryborough and its rapid thinning towards Childers. The isolated block near Gundiah has been mapped on the Maryborough 1:250,000 Sheet as Maryborough Formation. It contains *Meleagrinnella* sp. and is considered to be probably Neocomian. The faunas of the main body of the formation indicate an age of upper Aptian at the top, Aptian below. It is considered that the top part of the formation, which is the only part well exposed at the surface, was rapidly deposited in shallow, calm water, favourable for habitation by a dominantly pelecypod fauna, and the basin during this time suffered restriction of communication with the open sea and with other contemporaneous basins, possibly because it was nearly surrounded by land masses.

## INTRODUCTION

This is the third paper by the author dealing with the macrofauna of the Cretaceous Maryborough Formation of south-eastern Queensland. The first two dealt with palaeotaxodontid and arcoid pelecypods, and this paper records or redescibes the remainder of the macrofauna of the formation, to supplement these and other recent works and compares and contrasts it with other Lower Cretaceous faunas in eastern Australia. No new species are named. The trigoniid pelecypods of the formation were redescibed by Skwarko (1963) and the decapod crustacean, *Glypheia arborinsularis* Etheridge fil. by Woods (1957).

The species figured in this paper are:—

*Pseudavicula* sp.  
*Maccoyella alata* (Etheridge, 1872)  
*Meleagrinnella* sp.  
*Limea randsi* (Etheridge, 1872)  
*Camptochlamys* sp.  
*Camptonectes socialis?* (Moore, 1870)

*Myophorella* (M.) *australiana*

Skwarko, 1963

*Onestia etheridgei* (Etheridge fil., 1892)

*Tellina mariaeburiensis* Etheridge, 1872

*Fissilunula clarkei* (Moore, 1870)

*Panopea maccoyi* (Moore, 1870)

pelecypods

*Hemiasiter sweeti* (Etheridge fil., 1892)

spatangoid echinoid

*Rotularia?* sp.

polychaetian worm

**Stratigraphy and Localities:** The Maryborough Formation is a Lower Cretaceous marine and terrestrial unit exposed in the Bundaberg-Maryborough area and comprises the youngest known marine strata in the Maryborough Basin, a structural unit defined by Hill (1951) and recently commented upon by Ellis (1966). The formation was recently mapped in the Maryborough 1:250,000 Sheet area by Ellis (1969), who considers that an isolated block with *Meleagrinnella* sp. in the Gundiah area, 25 miles south-west of Maryborough, is part of the formation. The main body of the formation is folded in the Maryborough-Pialba area into a series of north-west plunging synclines and anticlines. From Maryborough, the west limb of the Burrum Syncline extends north-west and north toward Bundaberg, where the formation narrows in surface outcrop and decreases in thickness. Ellis gives the thickness of the formation as about 8,000 feet near Maryborough and about 1,800 feet in the Childers area (pers. comm.). Shell No. 1 (Gregory River) well penetrated about 8,000 feet of the formation (Shell, 1967); L.S.D. No. 1 (Cherwell) well penetrated about 6,000 feet; L.S.D. No. 2 (Susan River) was spudded in the Maryborough Formation and penetrated about 4,000 feet to the base. This provides evidence that the Maryborough Formation thickens eastward, particularly north of about 25°20'S latitude.

For this work, collections have been used from the Maryborough, Pialba, Woody Island, Childers and Gundiah areas. Smaller samples from other areas do not contribute significantly to the present study. The main fossil localities are shown on the map accompanying a previous publication (Fleming, 1966, p. 6). The Yengarie quarry locality is the lowest stratigraphically from which a useful collection has been obtained in the Maryborough area. It is estimated to be about one-third of the thickness above the base. Localities concerned specifically with type specimens of the species described in this paper are given with the individual species descriptions.

The material used is held by the Geological Survey of Queensland (G.S.Q.), the Queensland Museum (Q.M.), the University of Queensland (U.Q.), and the



Australian Museum, Sydney (A.M.). Fossil catalogue numbers of the institutions are given respectively as G.S.Q.F. —, Q.M.F. —, U.Q.F. — and A.M.F.—.

**Acknowledgements:** Thanks are due to Mr. J. T. Woods who assisted generously both as Director, Queensland Museum, and later as Chief Government Geologist, Geological Survey of Queensland; also to Mr. A. K. Denmead, formerly Chief Government Geologist, Geological Survey of Queensland, under whose leadership the work was started. Prof. Dorothy Hill, F.R.S., permitted me to use University of Queensland collections and facilities, and read the manuscript. Mr. H. O. Fletcher, formerly Deputy Director of the Australian Museum, permitted me to examine the collections in the Australian Museum and kindly lent material. Prof. C. Rossi Ronchetti of the University of Milan kindly supplied information, not otherwise available to me, regarding her molluscan work.

### AGE

The Maryborough Formation is considered to include strata ranging in age from not older than Neocomian to upper Aptian. The megafaunas provide the most useful information on age. An occurrence of microfossils near the boundary between the Maryborough Formation and Burrum Coal Measures is mentioned, but does not add a significant contribution; nor do the occurrences of microfossils in the wells which have penetrated the formation. The flora of the formation was described by Walkom (1918), who regarded it as Lower Cretaceous.

The fauna of the formation is considered in this section in three parts *viz.*: fauna of the Gundiah area, fauna of the lower parts of the main body of the formation, and fauna of the upper parts of the formation. These discussions are followed by a brief account of the fossils from wells.

**Gundiah area:**— *Meleagrinnella* sp. occurs in the area and is thought to indicate a Neocomian age. The species is very closely similar to, if not conspecific with, "*Pseudomonotis*" sp. from Stanwell, considered by Whitehouse (1946) to be Valanginian and by Skwarko (1966, p. 70) to be late Neocomian. I have been able to expose the hinge of Whitehouse's "*Pseudomonotis*" sp. and it has proved to be the same as that of *Meleagrinnella* sp. of this paper. Other occurrences of very closely similar forms are in the early Neocomian of the Dampier Peninsular (Brunnschweiler, 1960), in the Neocomian of the Laura Basin (Woods, 1963), and a single specimen in the Minmi Member, Aptian or possibly Neocomian, Surat Basin (Day, 1967). Probable marine Neocomian rocks are now known in four places along the eastern margin of Queensland; near Maryborough, Stanwell, in the Laura Basin, and in the Cape Weymouth 1:250,000 Sheet area at the eastern margin of the Carpentaria Basin (Fleming, 1965).

**Older part of main body of Maryborough Formation:**— The only collections from low in the formation are those from Yengarrie quarry and from the bottom of the formation on the Bruce Highway east of Childers. As far as the Childers locality is concerned, there are no forms to distinguish the collection from assemblages high in the formation, and no difference in age between the top and bottom of the formation at Childers can be recognized. The Yengarrie quarry assemblage, preserved in a soft mudstone with very high clay content, contains the forms shown in Table 2, column 1. The rock has been tested for microfossils by V. Palmieri, G.S.Q., with a negative result. The fauna contains typical Australian Aptian elements. Of those species thought to be restricted to the Aptian, marked "Apt." in Table 1, *Opisthotrigonia nasuta* (Etheridge, 1872) probably carries most weight as an indicator of age. The Yengarrie quarry fauna is considered to be a mudstone facies fauna (see section "Environment"). It has a high proportion of forms which seem to be typical of the Aptian elsewhere, and it contains no species known to occur in other stages. It is concluded, therefore, that this Yengarrie fauna is Aptian, but there is insufficient evidence to place it more exactly.

**Top part of Maryborough Formation:**— The fauna discussed under this heading is that of the part of the formation from the Copenhagen Bend locality to the top of the unit, and the exposures on Woody Island. This includes about 400 feet of strata in the Maryborough area and up to 560 feet on Woody Island (see Etheridge, 1917) with characteristically well preserved and abundant faunas. The megafaunal species are shown in Table 1. It seems from the present work that there are no useful distinctions in faunas at various levels over the interval mentioned, and no attempt has been made to analyse age differences in faunas over the interval.

*Australiceras jacki* (Eth. fil., 1880) occurs with other elements of the fauna in the top of the Maryborough Formation on Woody Island and indicates an upper Aptian age. All crioceratid species of *Australiceras* Whitehouse are declared by Casey (1960, p. 45 and text-fig. 5) to be upper Aptian. However, Skwarko (1966, p. 123, pl. 14, fig. 13) recorded a species like *A. jacki* from northern Australia and gave its age as probably late Neocomian. The specimen was apparently not associated with other fossils (Skwarko, *op. cit.*, table facing p. 56); and in the absence of palaeontological evidence to the contrary, *A. jacki* is accepted as an upper Aptian species.

The other cephalopods of the top of the Maryborough Formation are belemnites of the genus *Peratobelus*, probably with the species *P. oxys* (Tenison-Woods) represented. *Peratobelus* is a typically Aptian genus in the Great Artesian Basin (Day, 1964; Woods, 1961; Ludbrook, 1966; Skwarko, 1966).

The interesting species first described fully in this paper, *Hemiasper sweeti* (Eth. fil., 1892), is a spatangoid with features typical of forms of the Aptian and Albian in the Americas. It most closely resembles the



species *Epiaster dartoni* Cooke, 1955, from probable Aptian strata in Texas. The presence of *H. sweeti* is best regarded as sound evidence of post-Neocomian, but not necessarily pre-Albian, age for the upper fauna. Although Lower Cretaceous spatangoids are by no means rare in other continents, this is the only recorded occurrence of one in Australia.

In Table 1, those forms thought with some certainty to be restricted to the Aptian elsewhere than in the Maryborough Basin are marked "Apt". There is no form which could be called typically Albian or Neocomian according to published records.

**Wells and Borehole:**— Three oil exploration wells intersecting the Maryborough Formation have been drilled. All yielded microfaunas whose ages were given as follows:— L.S.D. (Cherwell) No. 1, Lower Cretaceous (Crespin, 1955); L.S.D. (Susan River) No. 2, Lower Cretaceous (Crespin, 1956); Shell (Gregory River) No. 1, Lower Cretaceous, probably Aptian (Shell Devt (Aust.) Pty Ltd, 1967). Microfloras in the Gregory River well are in Burrum Coal Measures down to 2,285 feet, and in the Maryborough Formation to 3,985 feet, below which no palynological work was carried out. The age above 2,621 feet is given by Dettmann (1967) as Lower Cretaceous, at 2,814 feet as Jura-Cretaceous, and below 2,814 feet as Mesozoic or indeterminate.

A small microfauna was found at a depth between 153 feet and 155 feet in G.S.Q. drill hole MV19 (Pialba 1-mile Sheet area 954333). In association with the microfossils is a pectinid, *Camptochlamys* sp., figured and described in this paper. V. Palmieri determined *Hedbergella infracretacea* (Glaessner), *Nodosaria nana* Reuss, *Trochammina raggatti*, Crespin, *Verneulinoides kansasensis* Loeblich and Tappan, *Saracenaria* sp., and *Rectoglandulina* sp.

These indicate an Aptian or Albian age. The faunule occurs at a level which must be very close to the boundary between the Maryborough and Burrum units as used in surface mapping, i.e. the top of the silicified strata sometimes referred to as "chert bed".

## ENVIRONMENTS

The Maryborough Formation consists of sandstone, mudstone and shale, with only one known layer of a dense, probably precipitated, limestone in one of the Lucky Strike wells. The fauna has been collected from surface outcrop, mainly from sandstone, but also from highly silicified mudstone and shale. The fossils from Yengarie quarry are the only collection to come from an apparently little-altered soft mudstone.

The Yengarie quarry assemblage (Table 2) has a high percentage of infaunal species. The number of species is small compared with assemblages from sandstone localities in the top part of the formation. Only *Maccoyella umbonalis* and the spiny-shelled *M. barklyi* do not appear to be infaunal species. The occurrence of these forms is rather surprising in this

association. They may have been able to cope with the very soft bottom conditions by remaining upright and partly buried, or by means of an efficient cleaning mechanism. They are hardly likely to have been transported into these muddy areas by currents, for there is no evidence of transportation; nor does it seem likely that the very heavy shell of *M. umbonalis* could have allowed it a free-swimming mode of life. The arcoid *Indogrammatodon robusta* may be epifaunal, but *Opisthotrignia nasuta* is probably infaunal, in the manner of trigoniids. The remainder of the bivalves, an overwhelming number of individuals and the majority of the species, are typical of forms living below the surface of mud; i.e., with thin, unornamented shells and, except for the palaeotaxodonts and *O. nasuta*, weak dentition. The Yengarie quarry assemblage has a good deal in common with that at Urraween railway station where the dominant faunal elements are infaunal types preserved in highly silicified, splintery mudstone. It is in the sandstones that the diversity of the fauna is greatest, and that epifaunal individuals equal or outnumber infaunal types.

The indications of the more diverse faunas, such as those occurring in the "glaucinitic" sandstones at Baddow and on Copenhagen Bend, are that the water was shallow, but not subject to strong wave or current disturbance. Shallow water is indicated by the fairly large numbers of specimens, their often thick-shelled and strongly ornamented forms, and by the absence of any apparently deep-water species. There are no obvious sedimentary features indicating depth of water. It is probable that the massive, unbedded character of the sandstones is due to the activity of burrowing organisms. There is much evidence of their activities in the sandstones, in the form of incompletely mixed sediment of different types, and sand-filled burrows. The amount of plant debris in the sediments is large, and could account for the great activity of burrowing organisms.

Infrequency of shell breakage or abrasion, common occurrence of bivalved shells not separated, and lack of any concentration or orientation of fossils, demonstrates that there was no strong current or wave influence in the environment. Some features are interpreted as indicating rapidity of sedimentation. Such features are burial of most epifaunal shells without abrasion of fine ornament, no overgrowth of sessile or encrusting benthos on shells, and common occurrence of plant debris in association with marine animals.

There are about 21 genera of bivalves in the Maryborough fauna, belonging to almost as many families. Only about six species of the benthos do not belong to the Bivalvia. The taxonomic diversity of the fauna does not appear to be very great, and in terms of the work of Stehli, McAlester and Helsley (1967) it is possible that the Maryborough Basin during the Aptian was a cold water province. However, there are several bivalve species present which are large, thick, or strongly ornamented, including the spinose specimens of *Maccoyella barklyi*, and this points to water of mild temperatures in terms of the findings of Nicol



(1967). Poor representation of cephalopods may indicate isolation of the basin. There does not appear to be any indication of very deep water in exposed parts of the formation.

It is likely that the low taxonomic diversity of the Maryborough fauna is due to isolation of the basin during the Aptian, with only a narrow seaway allowing faunal migration. Recent work has shown the probable presence of a high during the Lower Cretaceous, forming an eastern margin to the Maryborough Basin (Ellis, 1966).

Tables 1 and 2 were made up using the faunal lists of Day (1964, 1967) and Woods (1957, 1961). The numbers of species common to the Maryborough and the "Roma"\* Formations and the Minmi Member are very small in comparison with the total fauna of each unit. In the tables, the similarity is exaggerated by the use of the informal taxonomic category "form". If one

compares only identical species, the similarities are very slight. The fauna of the Blackdown Formation (Aptian, Carpentaria Basin) has about the same number of species in common with the Maryborough as do the "Roma" and Blythesdale Formations. Ammonites occur in abundance in the Blackdown Formation, and there may have been no barrier between that area and the open sea during the Aptian. It is evident that there was not continuous free communication between the Maryborough and other basins during the Aptian.

\*Vine *et al.* (1967) declared the use of the term "Roma" for a formation to be incorrect, but neither in that paper, nor in the paper by Vine and Day (1965), was any reference made to Day's (1964) redefinition of the Roma formation. Vine *et al.* (*op. cit.*) defined the Wallumbilla Formation which was used on the Roma 1:250,000 geological map. For the purposes of faunal comparison it is decided to retain the term "Roma Formation", since the precise relationship between Day's (1964) "Roma Formation" and the later "Wallumbilla Formation" has not been published.

TABLE 1

| FORMS/OCCURRENCES                                | I | Y | R | M | B |
|--------------------------------------------------|---|---|---|---|---|
| <i>Solemya</i> sp.                               | r | x |   |   | x |
| <i>Ennucula quadrata</i> (Eth.)                  | v | x |   |   |   |
| <i>Phaenodesmia elongata</i> (Eth.)              | v | x |   |   |   |
| <i>P. randsi</i> (Eth. fil.)                     | v | ? |   |   |   |
| <i>Indogrammatodon robusta</i> (Eth.) Apt.       | c | x |   |   | x |
| <i>Opisthotrigonia nasuta</i> (Eth.) Apt.        | c | x |   |   | x |
| <i>Myophorella australiana</i> Skwarko           | r |   |   |   |   |
| <i>Eyrena tatei</i> (Eth. fil.) Apt.             | r |   |   | x |   |
| <i>Pinna</i> cf. <i>P. australis</i> (Eth. fil.) | c |   |   |   | ? |
| <i>Linea randsi</i> (Eth. fil.)                  | v |   |   |   |   |
| <i>Camptonectes socialis</i> (Moore) Apt.        | v |   | x | x | x |
| <i>Maccoyella alata</i> (Eth.)                   | v |   |   |   |   |
| <i>M. corbiensis</i> (Moore) Apt.                | v |   | x |   |   |
| <i>M. umbonalis</i> (Moore) Apt.                 | v | x | x |   |   |
| <i>M. barklyi</i> (Moore) Apt.                   | c | x | x | x | x |
| <i>M. rostrata</i> Eth. fil. Apt.                | r |   | x |   |   |
| <i>Fissilunula clarkei</i> (Moore) Apt.          | r |   | x | x | x |
| <i>Pseudavicula anomala</i> (Moore) Apt.         | r |   | x | x | x |

Table 1. Fossils listed are those occurring in the upper parts of the Maryborough Formation. Column 1 gives an indication of their commonness or rarity in the beds (v - very common; c - common; r - rare). Columns Y, R, M and B show by crosses those species which occur at Yengarie quarry, in the "Roma Formation", the Minmi Member and the Blackdown Formation respectively. These comparisons are based mainly

| FORMS/OCCURRENCES                              | I | Y | R | M | B |
|------------------------------------------------|---|---|---|---|---|
| <i>Panopea maccoyi</i> (Moore) Apt.            | v | x | ? | x |   |
| <i>Onestia etheridgei</i> (Eth. fil.)          | c |   |   |   |   |
| " <i>Tellina</i> " <i>mariaeburiensis</i> Eth. | v |   |   |   |   |
| <i>Tancretella plana</i> (Moore) Apt.          | r | x | x | x | x |
| <i>Thracia primula?</i> Hudleston              | r | x |   | x |   |
| <i>Maranoana etheridgei</i> Day Apt.           | r | x | x | x | x |
| <i>Cyrenopsis opallites</i> Eth. fil.          | r |   |   |   |   |
| <i>Astarte</i> sp.                             | r |   | ? |   | ? |
| <i>Dentalium</i> sp.                           | r |   | x |   | x |
| <i>Euspira reflecta</i> (Moore) Apt.           | r |   |   | x |   |
| <i>Rotularia?</i> sp.                          | r |   |   |   |   |
| <i>Hemiaster sweeti</i> (Eth. fil.)            | r |   |   |   |   |
| Starfish- <i>Astropecten</i> Eth. fil. M.S.    | r |   |   |   |   |
| <i>Peratobelus</i> sp. Apt.                    | c |   | ? | ? | x |
| <i>Australiceras jacki</i> (Eth. fil.) Apt.    | r |   |   |   | x |
| Worm burrows and traces.                       | v |   |   |   |   |
| <i>Glyphea arborinsularis</i> Eth. fil. Apt.   | r |   | x |   |   |

on the faunal lists in Day (1964, 1967) and Woods (1957, 1961). A question mark indicates that it is very uncertain that a similar form is conspecific. Note that under Y are shown all the Yengarie forms known to me, but that the "Roma", Minmi and Blackdown units have faunas of 55, 25 and 47 species respectively. Data on faunas in the formations of the Eromanga Basin are not available.

TABLE 2

| FORMS/OCCURRENCES                     | I | R | M | B |
|---------------------------------------|---|---|---|---|
| <i>Solemya</i> sp.                    | r |   |   | x |
| <i>Ennucula quadrata</i> (Eth.)       | c |   |   |   |
| <i>Phaenodesmia elongata</i> (Eth.)   | c |   |   |   |
| <i>P. randsi</i> (Eth. fil.)          | ? |   |   |   |
| <i>Indogrammatodon robusta</i> (Eth.) | r |   |   | x |
| <i>Maccoyella barklyi</i> (Moore)     | c | x | x | x |
| <i>M. umbonalis</i> (Moore)           | r | x |   |   |

Table 2. Fossils listed occur in the Yengarie quarry exposures. Column 1 shows their rarity or commonness (r - rare; c - common). *P. randsi* is not certainly identified in the fauna. Columns R, M and B show by

| FORMS/OCCURRENCES                       | I   | R | M | B |
|-----------------------------------------|-----|---|---|---|
| <i>Opisthotrigonia nasuta</i> (Eth.)    | r-c |   |   | x |
| <i>Maranoana etheridgei</i> Day         | c   | x | x | x |
| <i>Tancretella plana</i> (Moore)        | c   | x | x | x |
| <i>Thracia primula?</i> Hudleston       | c   |   | x |   |
| <i>Panopea maccoyi</i> (Moore)          | r-c | ? | x |   |
| indet. thin shelled bivalves            | c   |   |   |   |
| <i>Glyphea arborinsularis</i> Eth. fil. | r   | x |   |   |

crosses those forms occurring in the "Roma Formation" Minmi Member of the Blythesdale Formation, and Blackdown Formation respectively. The occurrence of *P. maccoyi* in the "Roma Formation" is not certain.



To summarize, I regard the fauna of the top part of the Maryborough Formation as having lived in a shallow, calm sea of mild water temperatures, probably nearly landlocked, without significant east-west sea connection with the Surat Basin, and receiving sediment at a rapid rate.

### SYSTEMATIC DESCRIPTIONS

Class POLYCHAETA  
Family SERPULIDAE Burmeister, 1837  
Genus ROTULARIA DeFrance, 1827

*Type species*:— *Serpula spirulaea* Lam., 1818, Tertiary, Europe. Original designation.

*Rotularia?* sp.

Plate 1, fig. 1

*Remarks*:— The figured specimen is an external mould of an irregularly coiled planispiral tube which uncoils at about 15 mm spiral diameter. The tube is irregularly wrinkled, particularly on the uncoiled part where its diameter is about 5 mm. There is a lateral furrow which seems to persist from the early coils to the aperture. The surface is covered by fine granules. The test is similar in size and manner of growth to *Spirorbis leffingwelli* Imlay from the Albian Ignek Formation, Alaska.

Class BIVALVIA  
Family OXYTOMIDAE Ichikawa, 1958  
Genus MACCOYELLA Etheridge fil. 1892

*Type species*:— *Avicula barklyi* Moore, 1870, Aptian, Queensland. Original designation.

*Maccoyella alata* (Etheridge, 1872)

Pl. 1, figs 14-19

- 1872 *Avicula alata* Eth., p. 342, pl. 20, fig. 8.  
1892 *Pseudavicula alata* (Eth.). Eth. fil., p. 563, pl. 24, fig. 14.  
1902 *Maccoyella barklyi* Moore. Eth. fil., p. 11, partim.  
1968 *Maccoyella alata* (Eth.). Hill, Playford and Woods, pl. KVI, figs 14-15.

*Material*:— Holotype QMF1235. Several topotypes, G.S.Q. collection.

*Diagnosis*:— Thin shelled except in very large specimens which are thickened in umbonal region. Weakly inflated left valve, flat right valve, ribbing rather feeble, irregularly demarcated into primary, secondary and tertiary ribs. Posterior ear very large with horizontal dorsal margin. Byssal notch deep, separating very small right anterior ear. Teeth arranged as in typical *Maccoyella*, but rather weak.

*Description*:— Sizes range from 3 cm height and 5 cm length to 10 cm height and 14 cm length. Body of left valve subcircular with more gently arched hinge than in *M. barklyi*. Posterior ear very large, posterior

cardinal margin horizontal or inclined upward towards the rear. Left valve inflated by about 10 percent of its height. Umbo low. Right valve flat or weakly inflated, in shape broadly oval, with hinge margins behind and in front of umbo straight and set at angle of about 160° to each other. Left valve ornamented by rather weak ribs not clearly demarcated into primary and other orders with any regularity. Ribbing on ear more widely spaced than on body of shell. Ribs crossed by fine concentric lamellae. Ribbing on right valve similar but weaker; some specimens with weak secondaries inserted by intercalcation. Hinge gently arched in left valve, straight on each side of umbo in right valve. Byssal "comb" of separated shell lamellae on front of left valve hinge rather small. Byssal fold in right valve rather narrow and not as deeply folded as in type species. Hinge ligament and "teeth" typical of the genus, but not strongly developed as seen in Pl. 1, figs 16-19. On large specimens, whole hinge arrangement is much thickened and anterior tooth becomes a low, thick swelling. Umbonal cavity completely disappears with thickening.

*Remarks*:— *M. alata* is easily distinguished from other species of *Maccoyella* by its very large, flat posterior ear on the left valve. Right valves can be confused with those of *M. reflecta*, but have a more elongate posterior cardinal margin. *M. substriata* Moore (see Etheridge fil., 1892) has a large posterior ear, but with an upturned rear margin in the left valve. It has fewer ribs than *alata*, and an angular, overhanging umbo. The *M. reflecta* hinge is more robust than that of *alata*, with a rather deeper byssal notch. Etheridge fil. (1902) put *alata* in the synonymy of *barklyi*, but there seems now no doubt that they are separate species. *M. barklyi* occurs in the Maryborough Formation, but has stronger ornament, a more deeply folded byssal notch, a shorter, more arched hinge, and a much less extended posterior ear.

Genus PSEUDAVICULA Etheridge fil., 1892

*Type species*:— *Lucina anomala* Moore, 1870, Aptian, Queensland. Original designation.

*Pseudavicula* sp.

Pl. 1, fig. 13

- 1892 *Lima* sp. Eth. fil., p. 563, pl. 21, fig. 11.

*Remarks*:— The shell is small, about 13 mm high and 12 mm long, an external mould of a right valve. It has the typical shape of *Pseudavicula* and has cancellate ornament, with concentric ribs slightly more pronounced than radial ornament, and about 30 concentric ribs and numerous radials. It is the only specimen of the genus known to me from the Maryborough Basin, but *Pseudavicula* is represented abundantly by several species in other basins.

Genus MELEAGRINELLA Whitfield, 1885

*Type species*:— *Avicula curta* Hall, Jurassic, North America. Designation of Cox (1941).

*Meleagrinnella* sp.

Pl. 1, figs 8-12



1968 *Meleagrinnella* sp. Hill, Playford and Woods, pl. K VI, figs 16-17.

*Material*:— QMF5782-5785 and other specimens from a ridge in the Gundiah 1-mile sheet area, grid reference 675895.

*Description*:— Shell about 15 mm high and a little less in length. Left valve tumid, right valve weakly inflated. Ear of left valve small, sulci separating it from body of shell not sharp. Hinge margin of right valve fairly long and straight behind umbo, anterior ear of right valve very small, separated from body of valve by deep byssal notch directed forward and cutting back nearly to umbo. Left valve ornamented by costae of two orders, right valve by very weak costae of apparently only one order. Hinge of left valve differs in no really significant way from that of *Maccoyella barklyi*, the type of *Maccoyella*. The hinge plate is not as heavy, the anterior tooth not as strong, nor the margin of the anterior ear as strongly grooved as in *Maccoyella*. In the right valve, the posterior hinge margin is longer and straighter than in the type of *Maccoyella*, the anterior ear more produced, and the byssal notch not as oblique.

*Remarks*:— The species is morphologically very close to *Maccoyella* in its shape, ornament, hinge structure, and accommodation of the byssus in the shell. It differs significantly only in the lesser development of the anterior tooth of the left valve, and in the straighter cardinal margin and more forwardly directed, more nearly pectinoid anterior ear of the right valve.

*Meleagrinnella* sp. is a member of the late Jurassic-early Cretaceous group of species with simple outline and rather delicate ornament mentioned by Brunn-schweiler (1960, p. 20), who also pointed out (*op. cit.*, p. 17) the difficulties in assigning some of these forms to *Meleagrinnella* Whitfield. *Meleagrinnella* sp. is closely similar to two forms from the Laura Basin, considered by Woods (1963a,b) to be respectively of Neocomian and probably Neocomian age. Brunn-schweiler's (*op. cit.*) *Meleagrinnella* cf. *M. superstes* Spitz from the early Neocomian of Western Australia, and White-house's (1946) *Pseudomonotis* sp. from the Stanwell Neocomian, are very closely similar to the Laura Basin and Gundiah species. The only known local occurrence of such a form in possibly younger strata is in the marine Blythesdale Formation of the Surat Basin (Day, 1964). The hinge of the Stanwell specimens has been exposed during the present study and proves to be as described for *Meleagrinnella* sp. above.

Family LIMIDAE, d'Orbigny

Genus LIMEA Bronni, 1831

*Type species*:— *Ostrea strigillata* Broc., Tertiary, Europe.

*Limea randsi* (Etheridge fil., 1892)

Pl. 1, figs 2-3

1892 *Lima (Radula) randsi* Eth. fil., p. 562, pl. 21, fig. 13.

1902 *non Radula randsi* Eth. fil., p. 16, pl. 2, fig. 4.

1968 *Limea randsi* (Eth.). Hill, Playford and Woods, pl. K VI, fig. 7.

*Material*:— Holotype GSQF1406, Etheridge's figured specimen, Corporation Quarry, Maryborough. Numerous topotypes, G.S.Q. collection.

*Description*:— About as high as long (type about 25 mm). Inflation about 10-20 percent of height for a single valve. Shells prosocline, hinge short, ears small, posterior ear separated by sharp sulcus. Ornament of thirteen radial plications, about 1 mm wide and 1.5 mm apart near ventral margin. Larger plicae flat crested, laterals rounded. Plicae originate at umbo, and occasionally have weak ribs along their midlines. Exterior covered by fine, numerous growth lamellae which cross both crests and troughs of plicae. No musculature preserved on any specimens. Hinge straight, with obtuse auricular angulation at each end, cardinal area low, triangular, occupying length of hinge line. Very wide, deep, triangular ligament pit, about one third of hinge length at its lower margin. Two oblique denticles at each end of hinge line at the tops of the ears. Angle between cardinal area and plane of commissure about 30°.

*Remarks*:— This species seems to be characteristic of the Maryborough Formation, in the top part of which it occurs quite abundantly. It has not been reported from other Cretaceous formations in Australia. The denticles, by virtue of which it is here included in *Limea Bronni*, appear to be formed by an infolding of shell layers under the ends of the hinge margin. The feature does not seem to have been noted previously. I am indebted to Prof. C. Rossi Ronchetti for sending me photographs of the holotype of *O. strigillata*.

Family PECTINIDAE Lamarck

Genus CAMPTONECTES Meek, 1864

*Type species*:— *Pecten lens* J. Sowerby, Jurassic, England.

*Camptonectes socialis* (Moore, 1870)

*Remarks*:— This species is very common in the higher fauna of the Maryborough Formation. It grew to quite large size in the Maryborough Basin, specimens up to a height of 50 mm being not uncommon. The shells are typical of the genus *Camptonectes*, with very fine divaricating ribbing, and are probably conspecific with *C. socialis* from the Surat Basin.

Genus CAMPTOCHLAMYS Arkell, 1930

*Type species*:— *Pecten intertextus* Roemer, Jurassic, Europe.

*Camptochlamys* sp.

Pl. 1, fig. 7



- 1968 *Camptochlamys* sp. Hill, Playford and Woods, pl. KVI, fig. 13.

*Remarks:*— A few broken fragments of the species, together with the almost complete right valve figured, were found between 153 and 155 feet in drill hole MV19 mentioned previously (p. 3). The ornament of concentric lamellar ribs and radial lirae, with the deep, ridge-bordered subauricular groove, place it in Arkell's genus. In this species, the concentric ornament is stronger than the radial, in contrast with the much stronger radial ornament of the specimens of the type species figured by Arkell (1930, pl. 8, figs 1, 2). The stratigraphic position of this species is close to the top of the Maryborough Formation (see p. 3).

- Family TRIGONIIDAE Lam., 1819  
Subfamily MYOPHORELLINAE Kobayashi, 1954  
Genus MYOPHORELLA Bayle, 1878  
Subgenus MYOPHORELLA s. str.

*M. (Myophorella) australiana* Skwarko, 1963  
Pl. 1, fig. 6

- 1968 *M. (Myophorella) australiana* Skwarko. Hill, Playford and Woods, pl. K VI, fig. 8.

*Remarks:*— A more complete topotype than any of the specimens available to Skwarko (1963) has been found and is figured. This is another species seemingly restricted to the Maryborough Formation in Australia. *Opisthotrignia nasuta* (Eth.) is the other characteristic trigoniid of the formation, but occurs in the Great Artesian Basin as well.

- Superfamily CARDIACEA  
Genus ONESTIA McLearn, 1933

*Type species:*— *Laevicardium onestae* McLearn, 1931, by original designation. Lower Cretaceous, Canada.

*Onestia etheridgei* (Eth. fil., 1892)  
Pl. 2, figs. 1-4

- 1872 *Genus?* Eth. p. 339, pl. 19, fig. 4.  
1892 *Unicardium? etheridgei* Eth. fil., p. 569, pl. 27, fig. 1.  
1968 *Onestia etheridgei* (Eth. fil.). Hill, Playford and Woods, pl. K VI, figs 1a, b).

*Material:*— Holotype GSQF7477, from Corporation Quarry, Maryborough. QMF1258, figured by Etheridge Snr. (1872), from Maryborough. Several topotypes, G.S.Q. collection.

*Diagnosis:*— Large, broadly oval shell, with high, subcentral, tumid, acline umbos nearly meeting above hinge. Ornament of fine, irregular growth lines. Pallial line probably entire. Hinge cardioid, but with only a low, ridgelike anterior lateral in each valve. Hinge line broadly and evenly arched, with a strong posterior

lateral tooth in each valve. In right valve, central, erect, large cardinal tooth, with smaller, opisthocline cardinal in front of it. In left valve, anterior cardinal tooth large and triangular, with weak, prosocline cardinal behind it.

*Description:*— Outline broadly oval, with slightly depressed hinge line. Moderately inflated with maximum breadth about two thirds of height above venter. Umbo subcentral, high and incurved, umbonal cavity with thickening on slopes. Ornamented only by fine, irregular, concentric growth lines. Adductor muscle scars large, weakly impressed, set high under ends of hinge. Pedal muscle scar set in anterior of umbonal cavity just above level of hinge. (Apparent pallial sinus on holotype seems due to differential iron oxide deposition). Pallial line not certainly distinguishable but probably entire. Hinge cardioid, but with degenerate anterior laterals. Right valve: two cardinal teeth, strong posterior lateral, and low thick anterior lateral; both laterals continuous with subumbonal part of hinge plate; posterior cardinal erect, central, larger than opisthocline anterior cardinal; strong socket between cardinals, weaker socket behind; posterior lateral strongly projecting distally; anterior lateral is a heavy submarginal thickening rather than a tooth. Left valve: two cardinals and posterior lateral; anterior lateral of same form as in right valve; posterior lateral not as large as in right valve and fits above it; anterior cardinal large and triangular, posterior cardinal rather weak and prosocline.

*Remarks:*— *Onestia etheridgei* is fairly common in the upper part of the Maryborough Formation. Its tumid, orthocline shape, with high central umbos and strongly developed teeth distinguish it from the *Onestia* occurring in the Roma Formation and probably from the form in the Aptian to Albian of South Australia (Ludbrook, 1966, p. 183, pl. 83, fig. 11). The species from the Roma Formation has anterior umbos, is prosocline and has less robust, more finely sculptured teeth. The laterals particularly are not as strongly projecting and shelflike as in *etheridgei*. I am indebted to R. W. Day, formerly of the Australian National University, for indicating the generic location of the species.

- Superfamily TELLINACEA  
Family TELLINIDAE Deshayes  
Genus TELLINA Linnaeus, 1758

*Type species:* *Tellina radiata* Linnaeus, Recent, West Indian waters. Designation Children (1823).

*Tellina? mariaeburiensis* Eth., 1872  
Pl. 1, figs 4-5

- 1872 *Tellina mariaeburiensis* Eth., p. 341, pl. 20, figs 6, 6a.  
1872 *Tellina* sp. Eth. p. 341, pl. 20, fig 7.  
1892 *Palaeomoera mariaeburiensis* (Eth.). Eth. fil., p. 570.  
1892 *Palaeomoera* sp. indet. Eth. fil., p. 570, pl. 26, fig. 17.



- 1967? *P.?* *mariaeburiensis* (Eth.). Skwarko, p. 22, pl. 4, figs 6, 7.  
 1968 *T. mariaeburiensis* Eth. Hill, Playford and Woods, pl. K VI, fig 10.

*Material*:— Lectotype, here chosen, left valve whose internal and external moulds bear the numbers F1254 and F1255 in the Queensland Museum collection (Daintree collection, Maryborough). Etheridge's figure 6a of pl. 20 (1872) is probably based on this specimen. Other Q.M. collection specimens, F1256 and F1257, Daintree collection, were probably the originals of Etheridge's pl. 20, fig 6. Many topotypes, G.S.Q. collection.

*Description*:— Rather elongate, small, height about two thirds of length, moderately inflated. Posterior slightly truncated, umbo slightly raised above hinge line, weakly prosogyrous. Posterior umbonal slope bears low carina which continues to the base of the truncated posterior margin. Rear of test slightly flexed to the right. Ornament of raised growth lamellae distantly placed, with less raised, fine lamellae between. Shell has irregularly, coarsely banded appearance. All lamellae more distinctly raised on area above posterior carina. Musculature not preserved. Hinge margin feebly arched. GSQF9919, 9920, 9921 show part of the dentition of the species. Left valve: median cardinal socket, presumably bounded by two cardinal teeth; posterior lateral is continuous with hinge plate; it is a long shelflike process, upturned on the inner edge. Right valve: minute hinge plate; cardinals either very weak or much eroded; hinge plate buttressed under the umbo by oblique ridge in the posterior of the umbonal cavity; posterior lateral socket originates near the umbo, bounded below by a very weak lateral tooth.

*Remarks*:— Preparation of the specimens from the Maryborough Formation has revealed some of their hinge structure. These features, together with their shape and posterior deflection, confirms them as tellinids. I know of no modern revision of the tellinids, so, for the present, the species is tentatively assigned to *Tellina*.

There is doubt whether this species occurs in the other Cretaceous basins of Australia. Certainly, there are several small tellinids figured in the literature, but until their characters are known in more detail, it will not be possible to say whether they are conspecific with *mariaeburiensis*.

|             |                             |
|-------------|-----------------------------|
| Order       | PHOLADOMYOIDA               |
| Superfamily | PHOLADOMYACEA               |
| Family      | PHOLADOMYIDAE Fleming, 1828 |
| Genus       | FISSILUNULA Eth. fil., 1902 |

*Type species*:— *Cytherea clarkei* Moore, 1870, by monotypy. Aptian, Australia.

*Fissilunula clarkei* (Moore, 1870)

Pl. 2, figs 5-7, text fig. 1

- 1870 *Cytherea clarkei* Moore, p. 250, pl. 13, fig. 1.  
 1872 *Cyprina expansa* Eth., p. 338, pl. 19, fig. 1.  
 1892 *Cyprina clarkei* (Moore). Eth. fil., p. 474, p. 568, pl. 26, figs 18, 19, pl. 27, figs 9, 11 only.  
 1892 *Ceromya?* sp. ind. Eth. fil., p. 571, pl. 26, fig. 20.  
 1902 *Fissilunula clarkei* (Moore). Eth. fil., p. 36, pl. 6, fig. 3, pl. 19, fig 1, pl. 10, figs 1, 2, pl. 11, figs 1, 2.

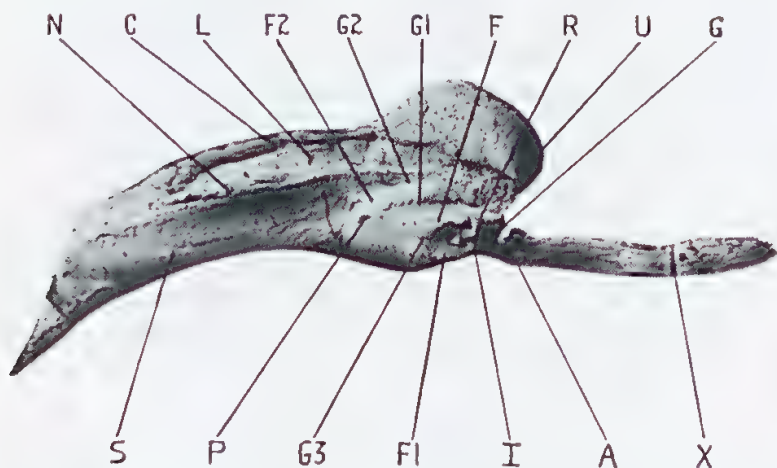
*Material*:— Type of *Cyprina expansa* Etheridge, QMF1250. Figured specimens from Maryborough of Etheridge fil. (1892). Other specimens, G.S.Q. and A.M. collections, from Maryborough area. See Ludbrook (1966) on fate of Moore's material.

*Diagnosis*:— Very large, oval, strongly inflated shell with anterior umbos directed forward and incurved so as to almost touch above hinge line. Probable slight overlap of right valve over left in rear part of dorsal region. Ornamented only by fine, irregular, concentric threads. Pallial sinus shallow and broad. Hinge much thickened, lacking true teeth, but with complex folds which protrude from the hinge line and evidently serve as teeth under and just behind the tip of the umbo. A crude posterior thickening on the hinge may serve as a posterior lateral tooth. The deep groove separating two sets of folds and originating under the tip of the umbo, crosses a horizontal area of shell fold in the position of a lunule. True lunule not present.

*Description*:— The ornament and some features of the hinge not previously described are shown on these Maryborough specimens. On the external mould of the specimen shown in pl. 2, fig. 5, the ornament consists of very fine, irregular, rounded, concentric threads. The specimen shows no signs of abrasion and is preserved with valves together. The specimen figured in pl. 2, figs 6 and 7 has most of the hinge of the left valve very well preserved. The hinge is a very remarkable structure, formed by complex folding of the shell margin. Text figure 1 shows the features referred to below. From beneath the tip of the umbo U, two grooves G and G1, extend into the hinge margin. G1 forms the dorsal boundary of the prominent fold F which projects forward and is recurved at its anterior end which forms the posterior boundary of groove G. The recurvature R is itself divided by a slight groove on its antero-ventral face into two folds, the inferior of which, I, lies against the blunt, projecting fold F1, which is bounded above, and separated from F, by a very shallow groove G3. The hole surrounded by F, F1 and I, may have been the site in life of a peak formed by amalgamation of the folds. It seems unlikely that a hole existed in the living shell. A third, posterior groove G2, almost parallel to G1, extends from beneath the tip of the umbo. It is separated from G1 by a low fold F2 which itself has a slight groove on its crest. In front of the groove G which is very deep, and completely cuts the hinge margin, there is a compact, fairly sharp fold A which is not as prominent as the fold complex F, F1 and I. The shell laminae at the base of F1 continue forward beneath G to the front of the hinge margin. On the rear upper surface of the large swelling produced by the F, F1, I complex, there is a vertical bladelike process P produced by an extension of the infolded laminae which produce G1.



The ligament area L is broad, bounded by a nymph N which is more prominent posteriorly. L is bounded on its outside margin by a channel C lying between L and the outer shell surface. There is a rather swollen line of shell S beneath the ligament area, emulating a posterior lateral. Unfortunately, the proximal part of the "lunule" and parts near it were broken in collection or at a later time. Little more is preserved on the external mould of the specimen figured in pl. 2, fig. 5. The hinge of the right valve was described by Etheridge Jr. (1902, pl. 10, fig. 2). Pallial sinus shallow, shown in pl. 2, figs 5 and 6. Pallial tongue rounded, no evidence of ventral musculature. No pallial attachment markings visible above adductors.



Text-fig 1. *Fissilunula clarkei* (Moore, 1870). Latex cast of left valve hinge (AMF 52153) showing the parts referred to in the description of the species. Nat. size.

**Remarks:**— The above description of the left valve hinge demonstrates that this shell is not a heterodont, but probably a desmodont in which the hinge folding has progressed to a remarkable degree. The prominent folds which apparently act as cardinal teeth are not in any way homologous with the cardinals of heterodonts. Etheridge fil. (1902b) in first describing the genus *Fissilunula* compared it with *Isocardia*, a heterodont genus with teeth much modified with strong prosogyration of the umbos. The structure described by Etheridge fil. (*op. cit.*) as a lunule is simply a more or less horizontal area of hinge margin extending from well in front of the umbo to the back end of the groove G1 in the above description, *i.e.* from well in front of the beak to well behind it. It is the exposed top part of the folded shell margin and is not a true lunule. The description given here is not in accord with that of the right valve given by Etheridge (1902b), in which there are supposed to be two grooves in front of the umbo and a deep groove behind. In the left valves described here, there are two grooves behind the umbo and a deep one about level with it. It is difficult to see how there could have been a good fit between valves such as those figured by Etheridge Jnr. and those from Maryborough, but it is possible if the fold complex F, F1, I engaged in the socket ax in Etheridge Jr's. figure 2 (Etheridge fil., *op. cit.*, pl. 10). However, in this case, the socket c d would appear to be too large to make a useful engagement with P in the Maryborough specimens. Day (1967, p. 14, text-fig. 3) treated the species as a heterodont Isocardiid, accepting Etheridge (1902b) comparison between *clarkei* and *Isocardia*.

Unfortunately, there are no right valves available from Maryborough showing the hinge, so the material is assigned to *F. clarkei*, of which Etheridge (1902b) described only the right valve, with some degree of doubt. Taking into consideration, though, the size and shape of the shells, their musculature, pallial sinus, ornament and grooved "lunules", it is a reasonable assignation.

It is difficult to assign the shells to a family. Hinges of pleuromyids, ceratomyids and related stocks are of simple form, and it is not difficult to see possible relationships between them and Palaeozoic edmondiids. Runnegar (1965, 1966) gives clear discussions of possible relationships among Palaeozoic and Mesozoic desmodonts. In searching for relationships of the present shells to other genera, significance is attached to the desmodont hinge, the weak pallial sinus, the opisthodontic ligament, the possible overlap of right valve over left, the concentric ornament, and the probable shallow burrowing mode of life. Some degree of overlap of right valve over left is suspected after examination of specimens from the Surat, Maryborough and Carpentaria Basins. Crushed specimens from the Maryborough Basin usually have the right valve crushed over the left, seemingly more often than would be coincidental. Uncrushed specimens from other basins sometimes show a small degree of overlap. In no case that I have seen has there been sufficient overlap to modify the ligament to the extent described by Runnegar (1965, pp. 230-231). These features seem to indicate a relationship of *Fissilunula* to the Pholadomyacea, but the hinge appears to be much more strongly and intricately folded than in other genera. Because of its apparent similarities to certain genera of Ceromyidae, *Fissilunula* is for the present placed in that family, although only tentatively. It is possible that a hinge such as that of *Fissilunula* could have been derived from one such as that of *Megadesmus* (see Runnegar, 1965). The first stage in such a derivation could be the complete infolding of the left valve socket to give groove G, together with an infolding on the front of the right valve tooth to give groove B of Etheridge's (1902b, pl. 10, fig. 2) specimen. A great deal more folding than that would have to occur, of course, and such a derivation will remain only speculation unless intermediate forms are described. The ligament appears to be almost exactly as Runnegar (*op. cit.* p. 234, fig. 2e) described in *Megadesmus*.

|             |                      |
|-------------|----------------------|
| Superfamily | HIATELLACEA          |
| Family      | HIATELLIDAE          |
| Genus       | PANOPEA Menard, 1807 |

**Type species:**— *Panopea aldrovandi* Menard, 1807, Recent, Mediterranean waters.

*Panopea maccoyi* (Moore, 1870)

Pl. 3, figs 1-4

- 1870 *Mya maccoyi* Moore, p. 253, pl. 13, fig. 8.
- 1872 *Panopaea sulcata* Eth., p. 342, pl. 21, figs 2, 2a.
- 1892 *Glycimeris sulcata* (Eth.). Eth. fil., p. 571, pl. 17, fig. 18.
- 1901 *G. maccoyi* (Moore). Eth. fil., p. 30.



**Material:**— Holotype lost (*vide* Ludbrook, 1966, p. 144, p. 170). Several specimens, all with valves together, from Maryborough area, G.S.Q. collection. Concerning the specimens figured by Etheridge Snr. (1872), it appears that only QMF1253 can be taken as type of *P. sulcata*. Its left valve is represented by Etheridge's pl. 21, fig. 2. According to the label with it, its right valve is the subject of pl. 21, fig. 2a, but the specimen and the figure bear little resemblance.

**Remarks:**— The specimen shown in pl. 3, fig. 1 is one of the few in the Maryborough Formation showing original shape. Most are crushed, more so than shells of other species, presumably because of their thin shells and infaunal habit. Crushing is frequently in the anterior-posterior direction, in accordance with an interpretation of their living posterior up in the sediment and being squashed during compaction of the unconsolidated sediment. The internal mould type specimen of *P. sulcata*, crushed from side to side, is figured in pl. 3, figs 3, 4. There do not seem to be any points of distinction between the Maryborough shells and those from the Surat Basin assigned by authors to *P. maccoyi*.

|          |                                               |
|----------|-----------------------------------------------|
| Order    | SPATANGOIDA                                   |
| Suborder | HEMIASTERINA                                  |
| Family   | HEMIASTERIDAE Clark, 1917                     |
| Genus    | HEMIASTER Agassiz, 1847 ( <i>sens. lato</i> ) |

**Type species:**— *Spatangus bufo* Brongniart, 1822, Cenomanian, France, designation of Savin (1903).

*Hemiaster sweeti* (Eth. fil., 1892)

Pl. 3, figs 5-11

1892 *Micraster sweeti* Eth. fil., p. 559.

1968 *Hemiaster sweeti* (Eth. fil.); Hill, Playford and Woods, pl. KX, figs 3-5.

**Material:**— No specimen was figured or specifically mentioned by Etheridge Jr. A new type will not be chosen for *H. sweeti* since there is no confusion regarding the species. Material used in this paper is a collection of topotypes from the G.S.Q.

**Diagnosis:**— Medium-sized hemiasteroid with shallow anterior sulcus and depressed petals. Mouth one-quarter of length of test from front, apical system not far behind centre of test. Mamelons perforate, surrounded by scrobicular tubercles, randomly distributed, and with granular tubercles between, except on peripetalous band. Band flush with adjoining adapical surface, about 4 mm wide, with crowded, fine granules and occasional tubercles. Apical system ethmophract, madreporite apparently extending all over right anterior genital plate. Four genital pores. Paired ambulacra of upper surface petaloid, rather open ended. Anterior ambulacrum with almost circular pores, and almost non-petaloid. Front pair of petals almost twice length of rear pair. Tube feet divided beyond petals, as far as about four plates from peristome. Plastron mesamphisternous. Labrum broadly triangular, with doubly indented distal edge. Sternals large. Peristome small, almost circular, no labral process.

**Description:**— All specimens crushed and shape not known with certainty. Apical system posterior. Shallow

anterior sulcus. Petals depressed. Mouth about one quarter of length of test from front. Anal position unknown. Tubercles on oral surface larger than those on apical surface except for a few on front ambulacrals. Tubercles grade in size and are distributed thickly in random fashion except in a peripetalous band where they are at random, but very rare. Mamelons perforate, surrounded by scrobicular tubercles. Intertubercular surface, except on peripetalous band, with granular tubercles. Peripetalous band with crowded, fine granules and occasional tubercles, flush with adjoining adapical surface. Band about 4 mm wide on a test 5.5 cm long. Apical system ethmophract, best preserved on F1224 which is a freak whose right anterior ambulacral column is missing (pl. 3, figs 10, 11). Madreporite appears to extend all over right anterior genital plate. Four genital pores. Paired ambulacra of adapical surface petaloid, rather open ended. Anterior ambulacrum with almost circular pores, almost non-petaloid. Posterior pore slits of front paired ambulacra longer than front slits of same ambulacra. Front pair of petals about twice as long as rear pair. Tube feet divided beyond the petals, as far as about four plates from the mouth. Traces of branching of tube feet as far as peristome on one specimen. Plastron broadly triangular, mesamphisternous. Labrum broadly triangular, with doubly indented distal edge. Sternals large, right slightly shorter than left, lateral margins slightly curved outward. Episternals and anal region not preserved. Peristome small, almost circular, no labral process.

**Remarks:**— This species is intermediate in character between Toxasteridae and Hemiasteridae, but cannot be assigned to any of the transitional genera mentioned by Fischer (1966, p. 557). It is most closely allied to species of *Hemiaster*, but does not have the fully developed fasciole of the genus. A species figured by Cooke (1955, p. 108, pl. 28, figs 1-10) as *Epiaster dartoni* Cooke is similar to *H. sweeti* except that its apex is more anterior and it is smaller. It has the same sort of "fasciole" or granular band, and comes from probable Aptian strata in Texas. Other species described by Cooke from the Albian are similar in shape, ornament, and in the presence of the broad, granular peripetalous band. They all possess the same type of plastron. All are referred to *Epiaster* or *Enallaster*, genera considered synonyms of *Heteraster* d'Orb. by Fischer (1966, p. 533). *E. dartoni*, however, does appear from Cooke's description and figure to be congeneric with *H. sweeti*.

The Lower Cretaceous spatangoids appear, from the works of Cooke (1946, 1955), to have a great deal in common in terms of shape, tuberculation, ambulacral arrangement, and plastron, and to be distinguished from the Upper Cretaceous Hemiasterina by having, in general, broader plastrons, less differentiated ornament, less specialized petal pores (particularly in the front ambulacrum), and less closed petals.

All the trends shown by Upper Cretaceous Hemiasterina are continued more strongly in the Tertiary. It is very difficult to make accurate comparisons with most of the described spatangoids from the Cretaceous of foreign countries. Most of the descriptions and figures are remarkably incomplete and did not anticipate the fine distinctions now used in dealing with the group.



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# EXPLANATION OF PLATE 1

(Figures natural size except where shown on plate. All except figures 7-12 from Baddow quarry area, Maryborough city).

- Figure 1 *Rotularia?* sp. GSQF7516. Grooved planispiral test with wrinkled collar near aperture.
- Figures 2-3 *Limea randsi* (Etheridge fil., 1892)
- 2 GSQF7463. Interior of left valve. Latex cast.
- 3 GSQF6742. Interior of cardinal region of left valve showing broad chondrophore and oblique toothlike processes on extremities of ears. Latex cast.
- Figures 4-5 *Tellina? mariaeburiensis* Etheridge, 1872
- 4 QMF1255. Lectotype. Exterior of left valve. Latex cast.
- 5 QMF1256. Exterior of left valve. Latex cast. Figured by Etheridge (1872).
- Figure 6 *Myophorella* (*Myophorella*) *australiana* Skwarko, 1963. GSQF7303. Left valve exterior. Latex cast.
- Figure 7 *Camptochlamys* sp. GSQF11274A. Exterior of right valve. Latex cast. G.S.Q. field bore hole MV19, 153'-155', Pinalba 1-mile Sheet area, grid reference 954333.
- Figures 8-12 *Meleagrinnella* sp. Probably Neocomian
- 8 QMF5785 Exterior of older part of left valve. Latex cast. Ridge, grid reference 675895, Gundiah 1-mile Sheet area.
- 9 QMF5782 Exterior of right valve. Latex cast. Same locality.
- 10 Same. Interior. Latex cast.
- 11,12 QMF5783 and QMF5784. Hinges of left valves showing hinge as in *Maccoyella*, but not developed to same extent in tooth formation. Latex casts. Same locality.
- Figure 13 *Pseudavicula* sp. GSQF1405. Exterior of right valve with very low relief cancellate ornament. Latex cast. Figured by Etheridge fil. (1892, pl. 21, fig. 11).
- Figures 14-19 *Maccoyella alata* (Etheridge, 1872).
- 14 GSQF6984. Exterior of right valve. Latex cast.
- 15 GSQF7588. Exterior of left valve. Latex cast.
- 16 GSQF7257. Interior of left valve. Large specimen with strongly produced ear and thickened hinge. Latex cast.
- 17 GSQF6996. Interior of left valve. Latex cast.
- 18 GSQF6981. Interior of upper region of right valve. Latex cast.
- 19 Same as 17. Enlarged, showing hinge region. Latex cast.



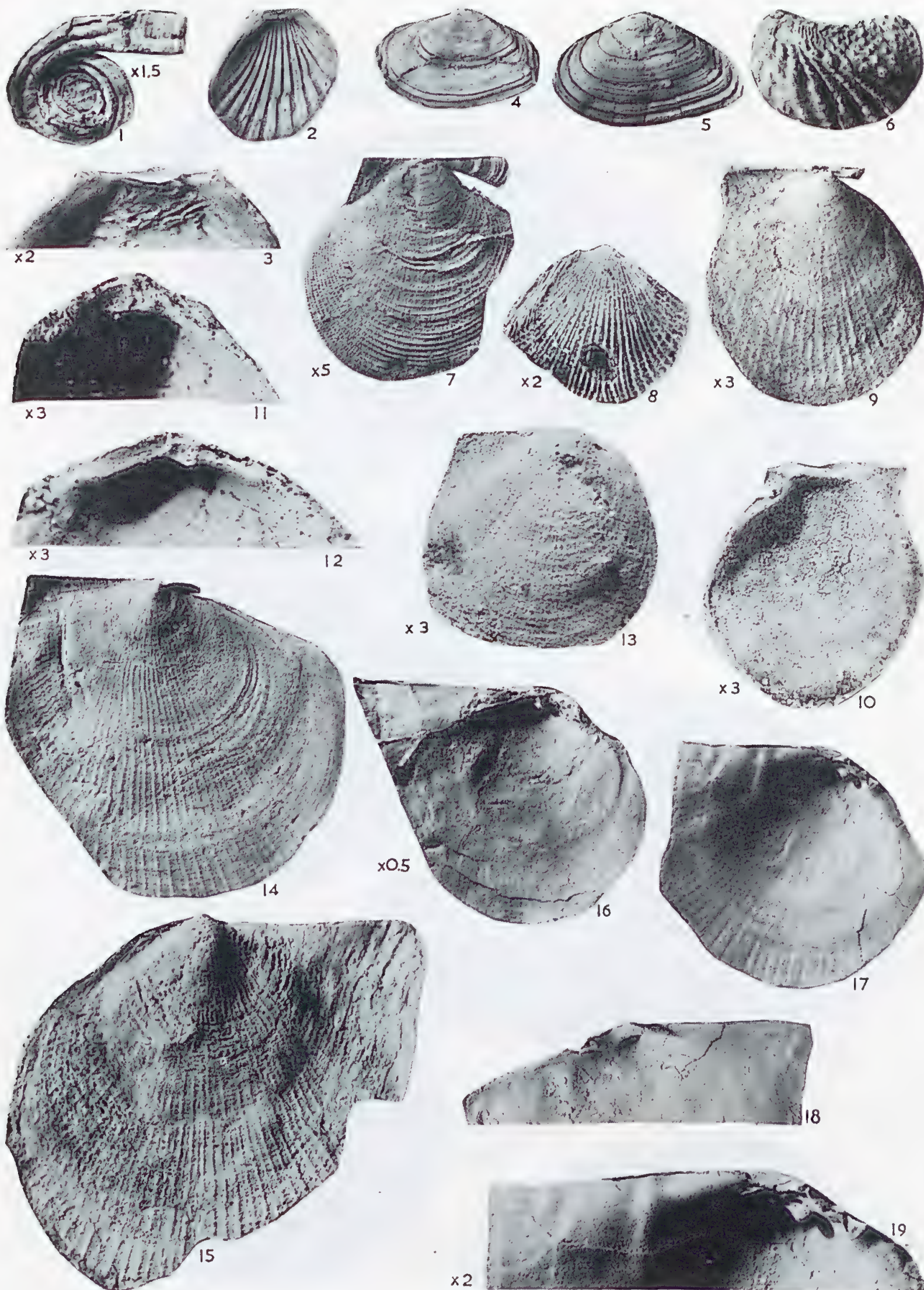


PLATE 1



## EXPLANATION OF PLATE 2

(Figures natural size except where marked on plate. All specimens from Baddow quarry area, Maryborough city)

Figures 1- 4 *Onestia etheridgei* (Eth. fil., 1892)

- 1 GSQF7326. Hinge of left valve, broken and displaced across anterior. Latex cast.
- 2 QMF1258. Interior of right valve, hinge broken similarly to that in Fig. 1. Latex cast.
- 3 Same. Internal mould. Figured by Etheridge (1872).
- 4 GSQF7477. Internal mould, valves displaced slightly. Figured by Etheridge fil. (1892).

Figures 5- 7 *Fissilunula clarkei* (Moore, 1870)

- 5 GSQF11212. Internal mould of left valve showing shape and shallow pallial sinus. Right valve also present in this specimen.
- 6 AMF52153. Internal mould of left valve with anterior broken.
- 7 Same. Hinge of left valve. Latex cast.



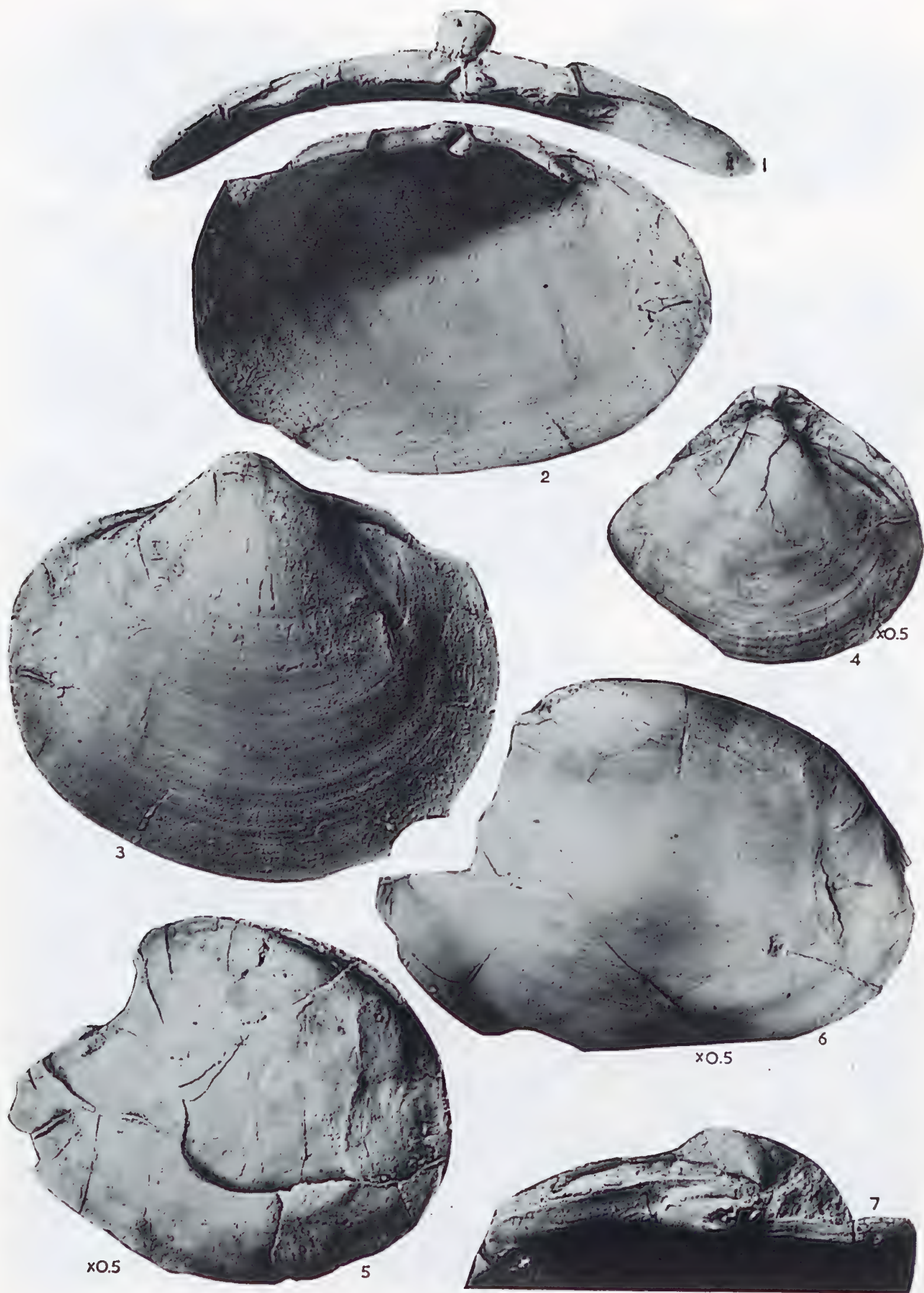


PLATE 2



### EXPLANATION OF PLATE 3

(Figures natural size except where indicated on plate. All specimens from Baddow quarry area, Maryborough city).

Figures 1- 4 *Panopea maccoyi* (Moore, 1870)

- 1 GSQF7476. Internal mould of left valve.
- 2 GSQF7491. Internal mould of left valve with "carina" due to crushing.
- 3, 4 QMF1253. Holotype of *P. sulcata* Etheridge, 1872. Thick left and right valves, crushed laterally.

Figures 5-11 *Hemiaster sweeti* (Etheridge fil., 1892)

- 5 GSQF1221. Internal mould of dorsum.
- 6 GSQF11211. Exterior of dorsum. Latex cast.
- 7 GSQF1221. Exterior of venter, all but plastron crushed. Latex cast.
- 8, 9 GSQF1219c. Exterior of dorsum showing position and detail of peripetalous granular band which has fewer tubercles than the more diffuse band of GSQF11211. Latex cast.
- 10, 11 GSQF1224. Detail and view respectively of internal mould of dorsum of freak specimen with right anterior ambulacrum missing. Gonopores four in number, right anterior contained in madreporite.



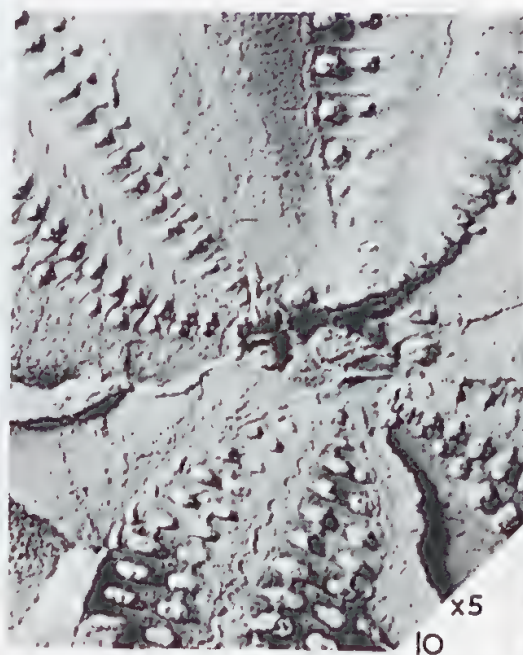
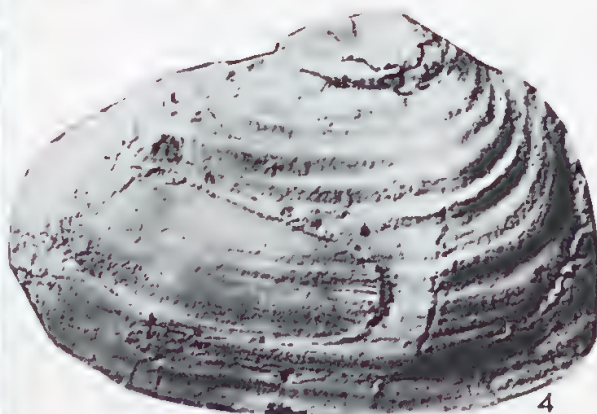
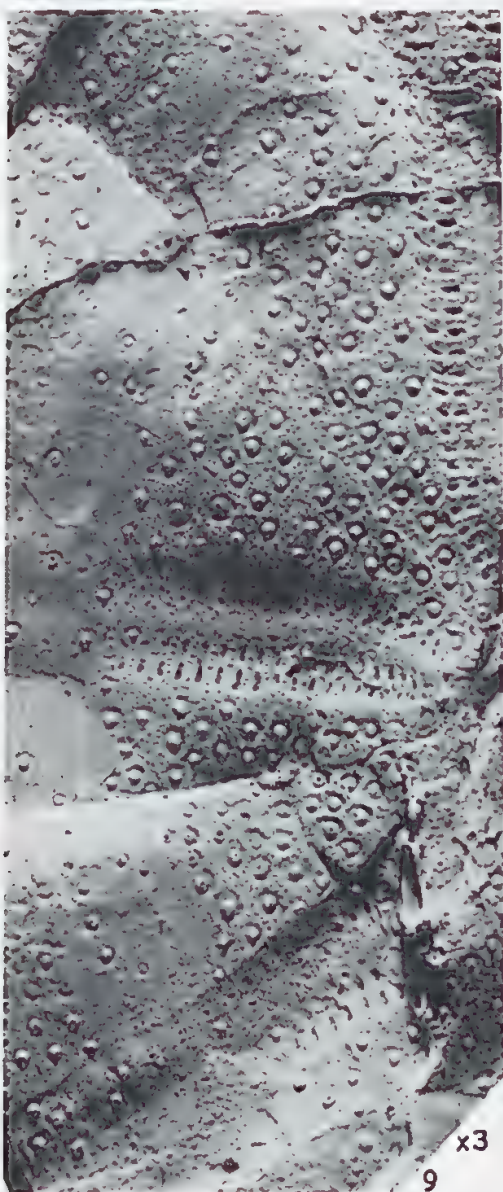
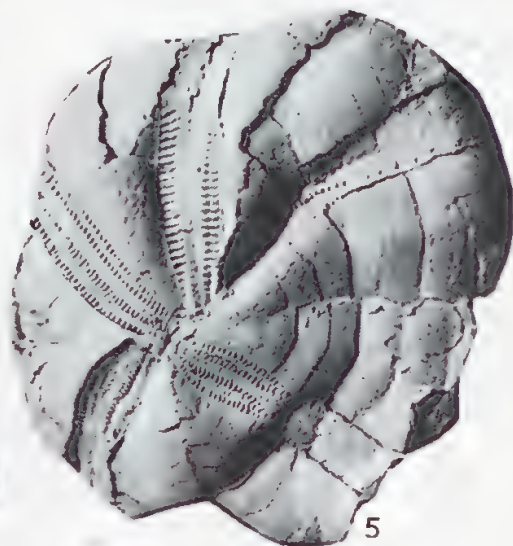
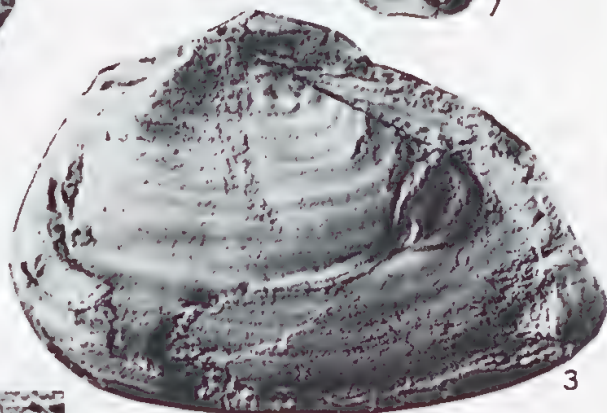
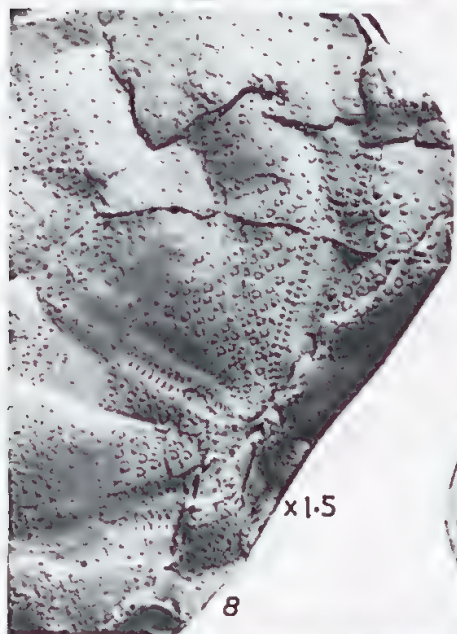
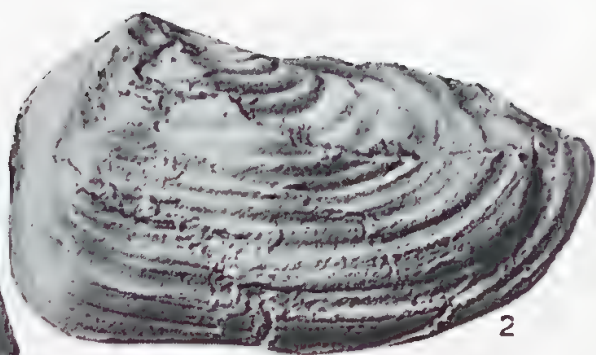
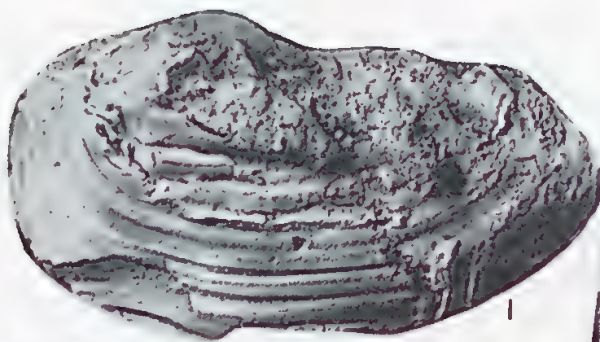


PLATE 3















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(J. T. Woods, Chief Government Geologist)

PUBLICATION No. 345  
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FROM THE REWAN FORMATION

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BRISBANE  
March, 1970





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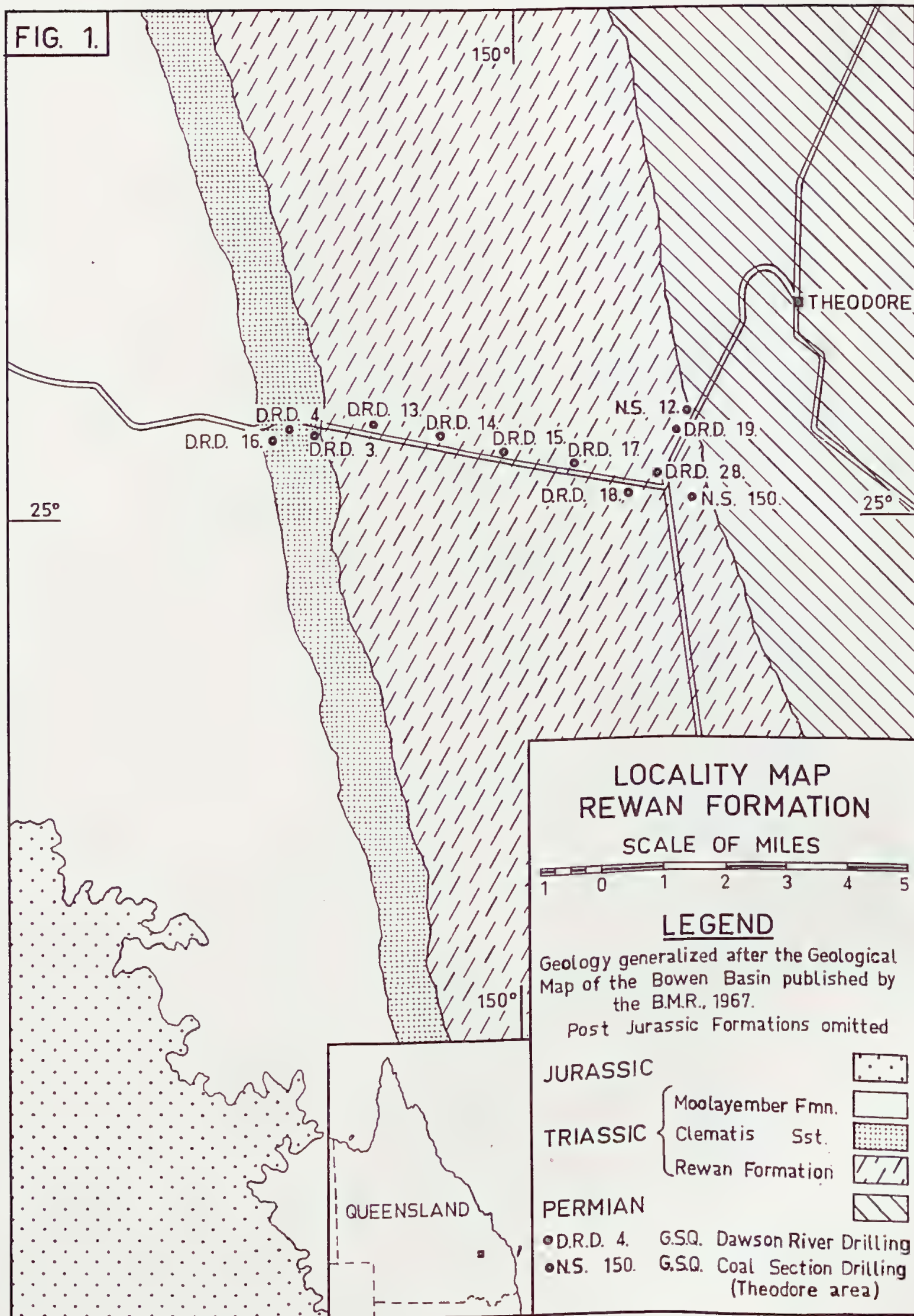
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# EARLY TRIASSIC MIOSPORES FROM THE REWAN FORMATION

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Geological Survey of Queensland

## ABSTRACT

Microfloral assemblages are described from the Rewan Formation, at the base of the Triassic sequence in the Bowen Basin of Queensland. The assemblages came from 64 samples of mudstone and shale, taken from a section about 9,000 feet in thickness, in the area where the Formation attains its thickest development, on the eastern side of the Mimosa Syncline.

Sixty-seven species of miospores are recorded. These include five new species, one of which is designated the type of a new genus, *Rewanispora*. This taxon is proposed for trilete cingulate spores with a foveolate distal exine. The other new species are assigned to the genera *Aratrisporites*, *Converrucosisporites*, *Grebespora*, and *Marsupipollenites*.

The effect of facies on composition of the assemblages is discussed; samples from within a section containing red-beds have yielded striate pollens in much greater abundance than those from the overlying section, in which *Aratrisporites* becomes abundant. Stratigraphic relationships of assemblages, within the section studied, are illustrated by a microfloral distribution chart and species of significance from this aspect are indicated. Comparison with other Triassic microfloras indicates a Scythian (Lower Triassic) age for the greater part of the sequence. Assignment of the basal part of the section, about 1,500 feet in thickness, to the Triassic is less conclusive and based on marked differences between the assemblages and those of underlying Permian strata. The investigation will provide a basis for correlation studies in sediments of similar age, elsewhere in the Bowen Basin.

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## INTRODUCTION

In the Bowen Basin, one of the major sedimentary basins of Queensland, there are thick and extensive deposits of Triassic sediments. These Triassic strata attain their thickest development in the southern part of the basin, where they are assigned to three units, which are, in ascending stratigraphic order, the Rewan Formation, Clematis Sandstone, and Moolayember Formation.

The Rewan Formation is distinguished from the overlying Clematis Sandstone by the finer grain size of the sediments, which are in general dominated by mudstone and shale. A characteristic feature of the Rewan lithology is the presence of red-beds (chocolate mudstone); these red-beds are confined to the Rewan Formation and their presence (together with the absence of persistent coal seams) assists in distinguishing the Formation from the underlying Permian coal measures. On the western side of the basin, in the Springsure area, the relationship to the underlying coal measures is probably disconformable, while on the eastern side the succession is conformable (Malone, 1964, p. 271). Likewise, there is a time break between the Rewan Formation and Clematis Sandstone on the Springsure Shelf (Mollan, 1967, p. 9); on the eastern side, in the Banana-Cracow area, the boundary is conformable and transitional (Malone, 1964, p. 271).

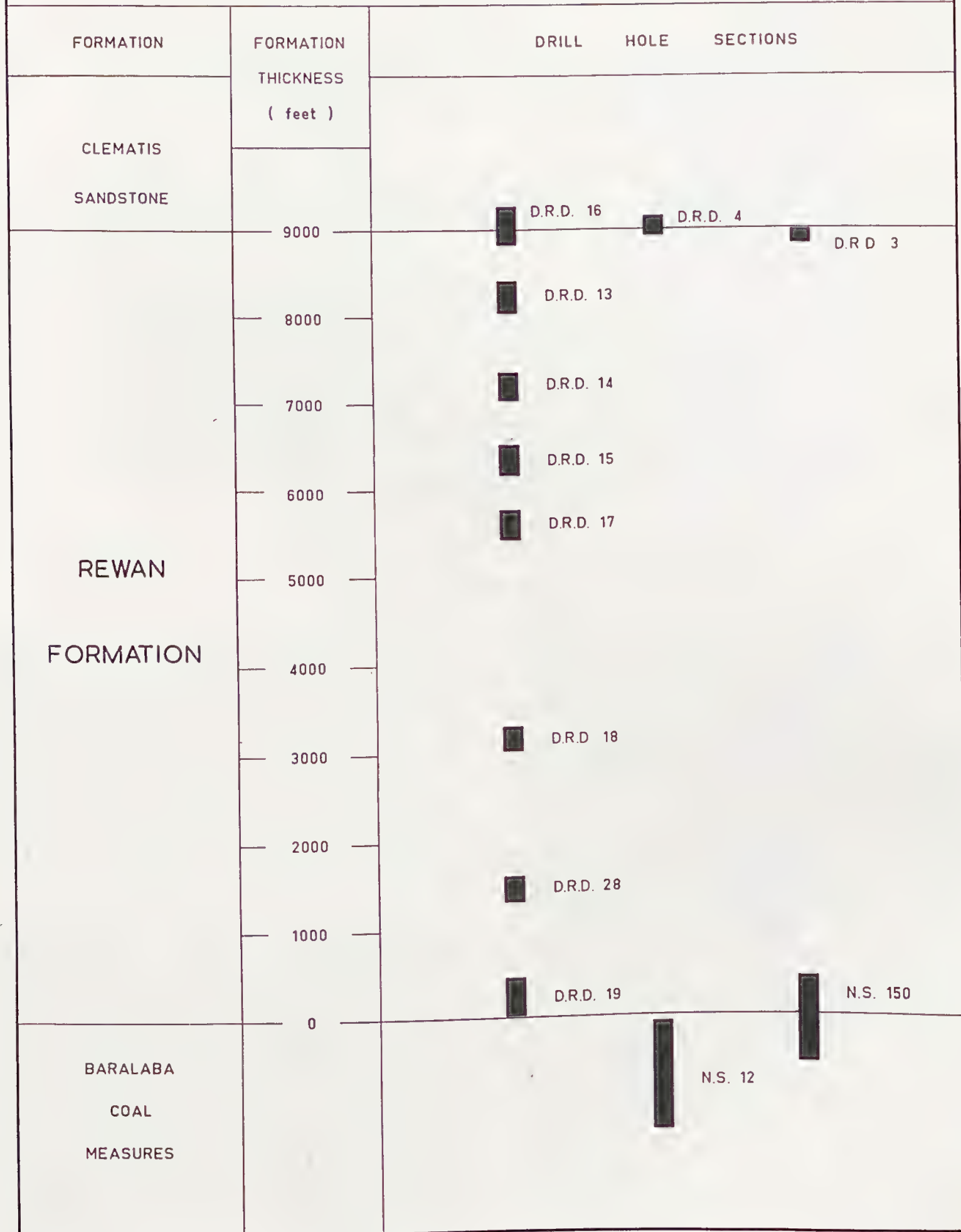
Although the Rewan sediments contain plant macrofossils (Mollan, 1967, Table 3) no detailed account of their morphology or stratigraphic significance has yet

been published. The only published record of the microflora is a brief discussion by Evans (1966, pp. 28, 29). In this paper the general composition of the Rewan assemblages is outlined, as a basis for their subdivision into four palynological units. The present paper thus constitutes the first detailed account of the morphology and stratigraphic distribution of plant microfossils from the Formation. In conjunction with previous papers on the Moolayember Formation (de Jersey and Hamilton, 1967) and Clematis Sandstone (de Jersey, 1968), it completes an initial study of Triassic microfloras of the Bowen Basin, based on the areas where the formations attain their maximum developments.

In its type section, the Rewan Formation is 1,700 feet in thickness (Mollan, 1967, Table 3). However, the type area is on the western side of the Basin, where the Triassic formations are thinning on the Springsure Shelf. Isopach studies indicate (Malone, 1964, p. 275) that the Formation attains its thickest development on the eastern side of the Basin, east of the axis of the Mimosa Syncline. Accordingly the present study has been based on samples from the eastern side of the Mimosa Syncline, in an area where the Rewan Formation is about 9,000 feet in thickness (W. Koppe, pers. comm.). By studying the thickest, most complete section available, it seems likely that it will provide a reference section, with which more attenuated developments of the Formation in other areas, may be correlated.

FIG. 2: STRATIGRAPHIC DISTRIBUTION  
OF DRILL HOLE SECTIONS

( W. Koppe , pers. comm. )





As in the Clematis and Moolayember investigations, a primary objective of the present study has been to record and describe species present in the assemblages, particular emphasis being placed on new species and species not previously recorded from Australia. The distribution of species in the assemblages, when related to this thick section of the Formation, has enabled the microfloral sequence to be recorded. This microfloral sequence should provide a basis for correlation studies, elsewhere in the Bowen Basin. In addition, comparison with other Triassic microfloras has provided evidence on the age of the Rewan Formation. The present paper should be regarded as an initial, rather than an exhaustive study of the Rewan microflora. Further study is likely to reveal additional species, and also to add to knowledge of species recorded. Likewise, from the biostratigraphic aspect, there is ample scope for more detailed study of the section investigated, or for study of assemblages from the Formation in other areas.

### STRATIGRAPHIC DISCUSSION

As indicated above, the section studied is in an area on the eastern side of the Mimosa Syncline, where the Rewan Formation attains its thickest development. As part of the stratigraphic drilling programme of the Geological Survey, nine holes were drilled initially, along a line across the outcrop of the Rewan Formation and Clematis Sandstone to the west of Theodore (see Locality Map—Figure 1). Of these, D.R.D.3 and D.R.D.4 were drilled in 1966, the remainder (D.R.D.13-19 inclusive) in 1967. These holes were spaced at regular intervals, on the assumption of a fairly uniform dip in the section. However cores from D.R.D.18 and D.R.D.19 indicated that the strata dip more steeply in the lower part of the Rewan succession, in this area. Accordingly an additional hole, D.R.D.28, was drilled in early 1969, to improve coverage of the lower part of the section. In addition, because D.R.D.19 did not penetrate sufficiently into the underlying Baralaba Coal Measures, material was studied from two holes drilled as part of the coal exploration programme of the Geological Survey. These were N.S.12 (Theodore) and N.S.150 (Theodore) which, taken in conjunction with D.R.D.19, provided coverage of the basal Rewan Section and the transition to the underlying Baralaba Coal Measures.

All these holes were continuously cored. They were drilled to various depths, generally of the order of 300 to 400 feet. On the basis of their locations, the regional stratigraphy and dip measurements made on the cores, the sections penetrated in these stratigraphic holes have been related to each other and assembled into one composite stratigraphic section (W. Koppe, pers. comm.). This composite section is shown diagrammatically in Figure 2. It will be evident from this diagram that there is good coverage of the uppermost and lowermost parts of the Rewan Formation and of the transition to the overlying and underlying formations, but that there are appreciable gaps in the sampling in the lower and middle parts of the Formation. Nevertheless, considering the relative thickness of this stratigraphic section, the available material is sufficient to provide data for recording the major features of the microfloral succession.

### PROCESSING OF SAMPLES

The core from these stratigraphic holes was sampled at regular intervals for processing. Most of the samples processed consisted of grey shale or mudstone. Attention was concentrated on such fine sediments because they gave the best yields of plant microfossils. Some samples of the red-beds (chocolate mudstone) were also processed, but the overall yield of carbonaceous material from all of them was extremely low. As only a small proportion of the carbonaceous residue from such samples consisted of plant microfossils, they were much less suitable than the associated grey shales and mudstones, for detailed study of the microflora.

The depths of samples from which useful assemblages were obtained, are recorded in the microfloral distribution diagram (Figure 3). Samples which were processed, but were barren, or almost barren, have been omitted. As about ten samples were normally processed for each of the stratigraphic holes, the number of samples recorded in Figure 3 gives an indication of the proportion of barren samples, in each case. The proportions of barren samples were highest in D.R.D.18 and D.R.D.19; only three samples from the former and one from the latter gave useful yields of plant microfossils.

Laboratory techniques employed in processing samples were similar to those adopted in the Moolayember and Clematis investigations (de Jersey and Hamilton, 1967, p. 2; de Jersey, 1968, p. 3). The microslides prepared were traversed systematically, 200 specimens being normally counted, so as to provide a basis for study of percentage distribution of the species. Generally, the preservation of the miospores was better in assemblages from the uppermost part of the Rewan sequence. In some of the assemblages from the middle and lower portions of the succession, the microfossils were poorly preserved, being slightly carbonized or having fine structure obscured by abrasion or corrosion. This poor preservation has had an adverse effect on biostratigraphic studies, as it has reduced the number of specific identifications in the assemblages concerned. Morphologic studies, which were concentrated on the better preserved assemblages, have been less affected.

In accordance with the writer's previous practice figured specimens are located by the stage co-ordinates of a Carl Zeiss GFL Microscope. In addition to the specimen co-ordinates, co-ordinates of a reference point, arbitrarily selected as the lower right hand corner of the cover glass are recorded in the text for each figured specimen. With this information the specimens can be readily located by means of any microscope equipped with a mechanical stage.

Microslides prepared during the investigation are stored in the collection of the Palynology Section, Geological Survey of Queensland. The numbers of the slides are preceded by the letter "S", indicating that they have been prepared from samples obtained in stratigraphic drilling.

### CLASSIFICATION OF MIOAPORES

The investigation has been restricted to miospores. These are the most abundant and most widely distributed of the plant microfossils in the maceration residues, and it is considered that they are the most useful from the



biostratigraphic aspect. Other microfossils observed include megaspores and acritarchs. Megaspores have been found in a few samples, particularly in those from D.R.D.3, in the uppermost part of the Rewan sequence. Acritarchs are more widely distributed, being present in about one-third of the assemblages studied. They occur sporadically, at horizons distributed through the Rewan section, in proportions which seldom exceed 1 or 2 per cent of the total microfossil assemblage.

Miospore genera recorded in this paper are arranged largely on the basis of the suprageneric classification of Potonié (1966). Although unanimity has yet to be achieved among palynologists on various aspects of suprageneric classification, it is considered that a detailed review of this subject is beyond the scope of this paper. The value of suprageneric form taxa lies mainly in their use in morphographic grouping of genera. Such grouping does not imply any natural relationship; as stated by Balme (1963, p. 15) "it seems unwise, at this stage of our knowledge of the morphology and affinities of fossil spores, to obscure possible natural relationships by over-rigid codification".

### SYSTEMATIC DESCRIPTIONS

Anteturma SPORITES H. Potonié, 1893

Turma TRILETES Reinsch *emend.* Dettmann, 1963

Subturma AZONOTRILETES Lubert *emend.* Dettmann, 1963

Infraturma LAEVIGATI Bennie and Kidston *emend.*  
Potonié, 1956

Genus BIRETISPORITES Delcourt and Sprumont *emend.*  
Delcourt, Dettmann and Hughes, 1963

*Type species:* *Biretisporites potoniaei* Delcourt and Sprumont, 1955.

*Biretisporites* sp. A

Plate 1, Figure 1

*Figured specimen:* Slide S1789, stage co-ordinates 14.9, 93.9, diameter 30 microns. Co-ordinates of lower right hand corner of cover glass 25.9, 83.3.

*Locality:* D.R.D. 19, 118 feet.

*Description:* Spores radial, trilete, amb convexly sub-triangular or triangular. Diameter (based on 5 measured specimens) 25 to 33 microns. Laesurae distinct, straight or slightly curved, length equal to or slightly less than, amb radius. Laesurae conspicuously lipped, lips comprising elevated proximal extensions of unthickened exine; laesurae in proximal view 2 to 6 microns in overall width and with undulating outer margins. Exine smooth, about 1 micron in thickness.

*Remarks:* Insufficient specimens of this species are available for formal taxonomic treatment. By reason of its smaller size and relatively longer laesurae, it is considered to be distinct, specifically, from specimens recorded as *Biretisporites* sp. by Playford (1965, p. 180) from the Triassic of Tasmania. As noted by that author (1965, p. 181) other records of the genus are from Cretaceous strata.

*Distribution:* Rewan Formation (this paper).

Genus CALAMOSPORA Schopf, Wilson and Bentall, 1944

*Type species:* *Calamospora hartungiana* Schopf, in Schopf, Wilson and Bentall, 1944.

*Calamospora tener* (Leschik) de Jersey, 1962

Plate 1, Figure 2

*Figured specimen:* Slide S1513, stage co-ordinates 19.9, 84.0; diameter 41 microns. Co-ordinates of lower right hand corner of cover glass 27.5, 92.0.

*Locality:* D.R.D.16, 526 feet.

*Remarks:* This species is relatively rare in the Rewan assemblages. Specimens observed conform closely to those previously recorded (Leschik, 1955, p. 13; de Jersey, 1962, pp. 3, 4; Mädlar, 1964, p. 92; de Jersey and Hamilton, 1967, p. 3; de Jersey, 1968, p. 4). In the specimen figured here (Plate 1, Figure 2) the relatively narrow lips are accentuated by adjacent folding.

*Distribution:* Upper Triassic of Switzerland (Leschik, 1955); Upper Triassic of Austria (Klaus, 1960); Triassic of Ipswich Coal Measures (de Jersey, 1962); Jurassic of Great Britain (Couper, 1958); Lower Keuper of West Germany (Mädlar, 1964); Middle and Upper Triassic and Lower Jurassic of East Germany (Schulz, 1966); Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

Genus CYATHIDITES Couper, 1953

*Type species:* *Cyathidites australis* Couper, 1953.

*Cyathidites breviradiatus* Helby, 1967

Plate 1, Figure 8

*Figured specimen:* Slide S1612, stage co-ordinates 13.0, 90.5; diameter 33 microns. Co-ordinates of lower right hand corner of cover glass 26.4, 82.5.

*Locality:* D.R.D.14, 306 feet.

*Remarks:* Specimens of *C. breviradiatus* from the Rewan Formation are similar to those previously recorded from the Clematis Sandstone (de Jersey, 1968, p. 4). Their size range (equatorial diameter, based on 28 measured specimens) is from 25 to 53 microns.

*Distribution:* Triassic of upper Wollar Sandstone and upper Narrabeen Group (Helby, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

Genus DICTYOPHYLLIDITES Couper *emend.*  
Dettmann, 1963

*Type species:* *Dictyophyllidites harrisii* Couper, 1958.

*Dictyophyllidites mortoni* (de Jersey)  
Playford and Dettmann, 1965

Plate 1, Figure 3

*Figured specimen:* Slide S1585, stage co-ordinates 6.7, 94.1; equatorial diameter 38 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 85.0.

*Locality:* D.R.D.13, 172 feet, 6 inches.

*Remarks:* Although its distribution is rather sporadic, the range of this species extends through the whole thickness of the Rewan Formation. The size range of the



Rewan specimens (equatorial diameter, based on 15 measured specimens) is from 30 to 50 microns.

*Distribution:* Triassic and Jurassic of south-east Queensland (de Jersey, 1959, 1962, 1963); Rhaeto-Liassic of Leigh Creek, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965); Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

Genus LEIOTRILETES (Naumova) Potonié and Kremp, 1954

*Type species:* *Leiotriletes sphaerotriangulus* (Loose) Potonié and Kremp, 1954.

*Leiotriletes directus* Balme and Hennelly, 1956

*Distribution:* Widely distributed in the Permian, Triassic and Jurassic of Australia (Balme and Playford, 1967); Triassic of Antarctica (Norris, 1965); Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

Genus RETUSOTRILETES Naumova, 1953

*Type species:* *Retusotriletes simplex* Naumova, 1953.

*Retusotriletes diversiformis* (Balme and Hennelly) Balme and Playford, 1967

*Remarks:* Only two specimens, assigned to this common Permian species, have been observed in the Rewan assemblages.

*Distribution:* Permian of Australia (Balme and Hennelly, 1956); Permian of Raniganj coalfield, India (Bhara-dwaj, 1962); Permian of Antarctica (Balme and Playford, 1967); Rewan Formation (this paper).

Genus STEREISPORITES Pflug, *emend.* de Jersey, 1964

*Type species:* *Stereisporites stereoides* (Potonié and Venitz) Pflug, 1953.

*Stereisporites antiquasporites* (Wilson and Webster) Dettmann, 1963

*Remarks:* A few spores of this simple, generalized type have been observed in the Rewan assemblages.

*Distribution:* Rewan Formation (this paper); Clematis Sandstone (de Jersey, 1968); Moolayember Formation (de Jersey and Hamilton, 1967); Upper Triassic of Bundamba Group (de Jersey, 1964); Jurassic and Lower Cretaceous of Western Australia (Balme, 1957); Jurassic of Precipice Sandstone and lower Evergreen Formation (de Jersey and Paten, 1964); Cretaceous of western Canada (Pocock, 1962); Cretaceous of south-eastern Australia (Dettmann, 1963); Tertiary of Montana (Wilson and Webster, 1946).

Infraturma APICULATI Bennie and Kidston *emend.* Potonié, 1956

Subinfraturma GRANULATI Dybová and Jachowicz, 1957

Genus GRANULATISPORITES Ibrahim *emend.* Potonié and Kremp, 1954

*Type species:* *Granulatisporites granulatus* Ibrahim, 1933.

*Granulatisporites micronodosus* Balme and Hennelly, 1956

Plate 1, Figure 9

*Figured specimen:* Slide S1786, stage co-ordinates 10.0, 96.5; diameter 40 microns. Co-ordinates of lower right hand corner of cover glass 25.5, 84.6.

*Locality:* D.R.D.19, 118 feet.

*Remarks:* This species, which is common in the underlying Upper Permian coal measures, persists in rare proportions into the Rewan sediments. It is suspected that some of the specimens observed, from horizons in the upper part of the Rewan sequence, have been re-worked from Permian assemblages.

*Distribution:* Widely distributed in the Permian of Australia (Balme and Hennelly, 1956); Permian of Antarctica (Balme and Playford, 1967); Rewan Formation (this paper).

Subinfraturma VERRUCATI Dybová and Jachowicz, 1957

Genus CONVERRUCOSISPORITES Potonié and Kremp, 1954

*Type species:* *Converrucosisporites triquetrus* (Ibrahim) Potonié and Kremp, 1954.

*Converrucosisporites cameroni* (de Jersey) Playford and Dettmann, 1965

Plate 1, Figure 7

*Figured specimen:* Slide S1465, stage co-ordinates 11.7, 88.4; diameter 44 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 82.4.

*Locality:* D.R.D.4, 195 feet, 5 inches.

*Remarks:* Although common in younger microfloras, e.g., those of the Ipswich Coal Measures, this species is relatively rare in the Rewan assemblages.

*Distribution:* Triassic of Ipswich Coal Measures (de Jersey, 1962); Upper Triassic of Bundamba Group (de Jersey, 1964); Rhaeto-Liassic of Leigh Creek Coal Measures (Playford and Dettmann, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); upper Rewan Formation (this paper).

*Converrucosisporites rewanensis* sp. nov.

Plate 1, Figures 4 and 5

*Synonym:* *Converrucosisporites* sp. A. de Jersey and Hamilton, 1969. Pl. 1, Fig. 2.

*Diagnosis:* Amb sub-triangular with broadly rounded apices and slightly concave sides. Diameter (based on 11 measured specimens) 43 to 63 microns. Trilete, laesurae distinct, straight or slightly curved, extending from about one-third to two-thirds radius of amb, without any marked development of lips. Distal exine with sculpture of low, inconspicuous verrucae, sub-circular to oval in basal outline, 1 micron or less in height, basal diameter about 1.5 to 5 microns. Distribution of sculptural



elements variable, showing variation among specimens from relatively regular arrangement over most of distal exine to the other extreme where elements are restricted mainly to radial apical regions. Proximal exine, apart from equatorial region, laevigate. Exine dark in colour, about 2 to 3 microns in thickness.

*Holotype* (Plate 1, Figure 5): Slide S1500, stage co-ordinates 19.5, 97.6; diameter 44 microns. Co-ordinates of lower right hand corner of cover glass 27.4, 82.6.

*Locality*: D.R.D.16, 388 feet, 6 inches.

*Figured specimen* (Plate 1, Figure 4): Slide S1533, stage co-ordinates 16.8, 84.2; diameter 49 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 82.8.

*Locality*: D.R.D.3, 92 feet, 11 inches.

*Remarks*: The low, inconspicuous verrucae, moderately thick exine and concave sides of the amb are distinctive features of this species. The specimens figured illustrate the variation in distribution of the sculptural elements; in the holotype (Plate 1, Figure 5) these are fairly evenly distributed, while in the other figured specimen (Plate 1, Figure 4) the verrucae are largely restricted to the radial (apical) regions.

*Converrucosisporites rewanensis* differs from *C. cameroni* (de Jersey) Playford and Dettmann, 1965, in having significantly lower sculptural elements, which consist solely of verrucae, in contrast to the diverse sculptural elements of that species, which comprise bacula, spinae, coni and grana, as well as verrucae. With its moderately thick exine, concave sides and relatively short laesurae it is reminiscent of *Cyathidites breviradiatus* Helby, 1967, but that species differs in being entirely laevigate. The Carboniferous species *Converrucosisporites mosaicoides* Potonié and Kremp (Potonié and Kremp, 1955, p. 64) has concave sides and laesurae of comparable length, but is appreciably smaller than the Rewan species and has smaller, more densely packed verrucae and a thinner exine. No close comparison can be made with other species of *Converrucosisporites*.

*Distribution*: Wandoan Formation (de Jersey and Hamilton, 1969); lower Clematis Sandstone, uppermost Rewan Formation (this paper).

Genus GUTTATISPORITES Visscher, 1966

*Type species*: *Guttatisporites guttatus* Visscher, 1966.  
*Guttatisporites visscheri* de Jersey, 1968

*Remarks*: This species is relatively rare in the Rewan assemblages. It has been recorded only from horizons in the upper part of the Formation.

*Distribution*: Lower Moolayember Formation, Clematis Sandstone (de Jersey, 1968); Upper Rewan Formation (this paper).

Subinfraturma NODATI Dybová and Jachowicz, 1967

Genus ACANTHOTRILETES Naumova *emend.*  
Potonié and Kremp, 1954

*Type species*: *Acanthotriletes ciliatus* (Knox) Potonié and Kremp, 1954.

*Acanthotriletes tereteangulatus* Balme and Hennelly, 1956

Plate 1, Figure 6

*Figured specimen*: Slide S1785, stage co-ordinates 7.8, 85.5; diameter 38 microns. Co-ordinates of lower right hand corner of cover glass 25.7, 80.7.

*Locality*: D.R.D.19, 188 feet.

*Remarks*: Rare specimens of this species are present, mainly in the basal part of the Rewan Formation.

*Distribution*: Permian of Australia (Balme and Hennelly, 1956); Permian of Antarctica (Balme and Playford, 1967); Rewan Formation (this paper).

Genus DIDECITRILETES Venkatachala and Kar, 1965

*Type species*: *Didecitriletes horridus* Venkatachala and Kar, 1965.

*Didecitriletes ericianus* (Balme and Hennelly)  
Venkatachala and Kar, 1965

*Remarks*: This species (common in Australian Permian microfloras) is a rare component of the Rewan assemblages.

*Distribution*: Permian of Australia (Balme and Hennelly, 1956); Permian of Raniganj coalfield, India (Bharadwaj, 1962); Permian of Antarctica (Balme and Playford, 1967); Rewan Formation (this paper).

Genus LOPHOTRILETES (Naumova) Potonié and Kremp, 1954

*Type species*: *Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp, 1954.

*Lophotriletes bauhiniae* de Jersey and Hamilton, 1967

*Remarks*: This species is relatively rare in the Rewan assemblages and confined to the upper part of the Formation.

*Distribution*: Lower Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); upper Rewan Formation (this paper).

Genus OSMUNDACIDITES Couper, 1953

*Type species*: *Osmundacidites wellmanii* Couper, 1953.  
*Osmundacidites fissus* (Leschik) Playford, 1965

Plate 1, Figure 10

*Figured specimen*: Slide S1542, stage co-ordinates 17.0, 85.5; equatorial diameter 44 microns. Co-ordinates of lower right hand corner of cover glass 26.2, 83.7.

*Locality*: D.R.D.3, 113 feet, 5 inches.

*Remarks*: The Rewan specimens are similar to spores of this species described by Playford (1965, p. 182) from the Triassic of Tasmania. Their size range (equatorial diameter, based on 26 measured specimens) is from 23 to 49 microns. Distinctive features of this species are the very fine, dense sculpture and the well defined, lipped laesurae.

*Distribution*: Middle Keuper of Switzerland (Leschik, 1955); Triassic of Tasmania (Playford, 1965); Rewan Formation (this paper).



*Osmundacidites senectus* Balme, 1963

Plate 1, Figure 11

*Figured specimen:* Slide S1739, stage co-ordinates 26.4, 100.2; diameter 74 microns. Co-ordinates of lower right hand corner of cover glass 27.4, 84.1.

*Locality:* D.R.D.17, 234 feet, 11 inches.

*Remarks:* This species is a rare component of the Rewan assemblages.

*Distribution:* Lower and (?) Middle Triassic of Western Australia (Balme, 1963); Narrabeen Group of New South Wales (Balme, 1963); Rewan Formation (this paper).

Infraturma MURORNATI Potonié and Kremp, 1954

Genus TIGRISPORITES Klaus, 1960

*Type species:* *Tigrisporites halleinis* Klaus, 1960.

*Tigrisporites playfordi* de Jersey and Hamilton, 1967

Plate 2, Figure 8

*Figured specimen:* Slide S1600, stage co-ordinates 15.8, 96.7; diameter 41 microns. Co-ordinates of lower right hand corner of cover glass 27.3, 86.2.

*Locality:* D.R.D.13, 107 feet, 8 inches.

*Remarks:* This species is a rare component of the Rewan assemblages. The specimens observed are quite similar to those recorded from the Moolayember Formation (de Jersey and Hamilton, 1967, p. 10) and Clematis Sandstone (de Jersey, 1968, p. 8). Their size range (mean diameter, based on 8 measured specimens) is from 26 to 41 microns.

*Distribution:* Triassic of Tiers Formation, Tasmania (Playford, 1965); Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

Turma ZONALES Bennie and Kidston *emend.* Potonié, 1956

Subturma AURITOTRILETES Potonié and Kremp, 1954

Infraturma AURICULATI Schopf *emend.* Dettmann, 1963

Genus INDOSPORA Bharadwaj *emend.* de Jersey, 1968

*Type species:* *Indospora clara* Bharadwaj, 1962.

*Indospora clara* Bharadwaj, 1962

Plate 2, Figure 7

*Figured specimen:* Slide S1605, stage co-ordinates 22.1, 93.6; diameter 49 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 84.1.

*Locality:* D.R.D. 13, 82 feet, 7 inches.

*Remarks:* Like specimens previously described from the Clematis Sandstone (de Jersey, 1968, pp. 8, 9) the Rewan specimens exhibit all the significant diagnostic features of *I. clara* Bharadwaj.

*Distribution:* Upper Permian of Raniganj Coalfield, India (Bharadwaj, 1962); Triassic of Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

*Indospora reticulata* de Jersey, 1968

Plate 2, Figures 9 and 10

*Figured specimen (Figure 9—distal focus, Figure 10—equatorial focus):* Slide S1561, stage co-ordinates 19.2, 94.0; diameter 49 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 81.6.

*Locality:* D.R.D.3, 127 feet, 7 inches.

*Remarks:* The Rewan specimens are similar to those previously described from the Clematis Sandstone (de Jersey, 1968, p. 9).

*Distribution:* Lower Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

Subturma ZONOTRILETES Waltz, 1935

Infraturma CINGULATI Potonié and Klaus, 1954

Genus DENSOISPORITES Weyland and Krieger  
*emend.* Dettmann, 1963

*Type species:* *Densoisporites velatus* Weyland and Krieger *emend.* Krasnova, 1961.

*Densoisporites playfordi* (Balme) Dettmann, 1963

Plate 2, Figure 1

*Figured specimen:* Slide S1725, stage co-ordinates 6.9, 97.6; overall equatorial diameter 41 microns; diameter of intexine 23 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 84.0.

*Locality:* D.R.D.17, 272 feet, 4 inches.

*Remarks:* Specimens of this species closely resemble those previously recorded from the Clematis Sandstone (de Jersey, 1968, p. 10) and Moolayember Formation (de Jersey and Hamilton, 1967, p. 12). Their size range (based on 30 measured specimens) is from 30 to 61 microns (overall equatorial diameter); the diameter of the intexine ranges from 18 to 36 microns.

*Distribution:* Lower and (?) Middle Triassic of Western Australia (Balme, 1963); Ross Formation (Lower Triassic) of Tasmania (Playford, 1965); Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

cf. *Densoisporites* sp.

Plate 2, Figure 6

*Figured specimen:* Slide S1894, stage co-ordinates 6.1, 98.0; overall equatorial diameter 40 microns; diameter of intexine 26 microns. Co-ordinates of lower right hand corner of cover glass 26.0, 81.5.

*Locality:* N.S.150 (Théodore), 420 feet, 2 inches.

*Remarks:* The specimen figured is representative of spores which resemble *Densoisporites playfordi*, except for the exoexine being appreciably thinner (at the equator) and smooth or very faintly patterned. Because of the latter feature they are compared, rather than identified, with *Densoisporites*. They may be poorly preserved (corroded or overmacerated) specimens of *D. playfordi*.



These specimens are of stratigraphic interest in that the level of their first appearance is close to the base of the Rewan Formation (as indicated by the horizon of the specimen figured). Definite specimens of *D. playfordi*, on the other hand, make their first appearance appreciably higher in the sequence, in assemblages from D.R.D.28.

Genus *KRAEUSELISPORITES* Leschik *emend.* Jansonius, 1962

*Type species: Kraeuselisporites dentatus* Leschik, 1955.

*Kraeuselisporites cuspidus* Balme, 1963

Plate 3, Figure 2

*Figured specimen:* Slide S1775, stage co-ordinates 19.1, 89.5; overall equatorial diameter 63 microns; diameter of intexine 38 microns. Co-ordinates of lower right hand corner of cover glass 27.0, 83.8.

*Locality:* D.R.D.18, 119 feet, 1 inch.

*Remarks:* Two specimens identifiable with this species, both in assemblages from D.R.D.18, have been observed in the Rewan material.

*Distribution:* Kockatea Shale (Lower Triassic) of Western Australia (Balme, 1963); Ross Formation (Lower Triassic) of Tasmania (Playford, 1965); lower Rewan Formation (this paper).

*Kraeuselisporites saeptatus* Balme, 1963

Plate 3, Figure 1

*Figured specimen:* Slide S1721, stage co-ordinates 21.0, 91.7; overall equatorial diameter 71 microns; diameter of intexine 46 microns. Co-ordinates of lower right hand corner of cover glass 27.1, 84.8.

*Locality:* D.R.D.17, 284 feet, 5 inches.

*Remarks:* The Rewan specimens conform closely to the description and figures of Balme (1963, pp. 20, 21). Their dimensions (based on 12 measured specimens) are overall equatorial diameter, 46 to 71 microns; diameter of intexine 30 to 51 microns; width of zona 8 to 15 microns.

*Distribution:* Lower Triassic of Western Australia (Balme, 1963); Rewan Formation (this paper).

*Kraeuselisporites* sp. (indet.)

*Remarks:* Under this heading are recorded poorly preserved specimens of the genus. Some, at least, of them may be identifiable with *K. differens* Helby, which has been recorded from the overlying Clematis Sandstone (de Jersey, 1968, p. 10), but their preservation is too poor to establish this with certainty.

Genus *LUNDBLADISPORA* Balme *emend.* Playford, 1965

*Type species: Lundbladispورا willmotti* Balme, 1963.

*Lundbladispورا brevicula* Balme, 1963

Plate 2, Figure 4

*Figured specimen:* Slide S1691, stage co-ordinates 19.0, 93.5; overall equatorial diameter 35 microns; diameter of intexine 21 microns. Co-ordinates of lower right hand corner of cover glass 25.9, 82.0.

*Locality:* D.R.D.15, 109 feet, 3 inches.

*Remarks:* Only two specimens of this species have been observed in the assemblages studied. They exhibit the diagnostic characters of *L. brevicula* recorded by Balme (1963, p. 24) and Playford (1965, p. 190). As stated by the latter author, the most obvious distinction between this species and *L. willmotti* Balme lies in its possessing more prominently lipped and longer laesurae.

*Distribution:* Kockatea Shale (Scythian) of Western Australia (Balme, 1963); Ross Formation (Lower Triassic) of Tasmania (Playford, 1965); Rewan Formation (this paper).

*Lundbladispورا willmotti* Balme, 1963

Plate 2, Figure 5

*Figured specimen:* Slide S1734, stage co-ordinates 17.4, 96.5; diameter 51 microns, diameter of intexine 43 microns. Co-ordinates of lower right hand corner of cover glass 26.4, 84.7.

*Locality:* D.R.D.17, 270 feet, 6 inches.

*Remarks:* The Rewan specimens conform closely to the description and figures of Balme (1963, pp. 22, 23) and Playford (1965, pp. 190, 191).

*Distribution:* Kockatea Shale (Lower Triassic) of Western Australia (Balme, 1963); Ross Formation (Lower Triassic) of Tasmania (Playford, 1965); Rewan Formation (this paper).

*Lundbladispورا* sp.

Plate 2, Figure 3

*Figured specimen:* Slide S1891, stage co-ordinates 20.0, 82.5; overall equatorial diameter 43 microns, diameter of intexine 26 microns. Co-ordinates of lower right hand corner of cover glass 27.5, 82.5.

*Locality:* N.S.150 (Theodore), 420 feet, 2 inches.

*Remarks:* The specimen figured resembles *L. willmotti* in the character and size of the sculptural processes, but differs from that species in being somewhat below the size ranges quoted by Balme (1963, p. 22) or Playford (1965, p. 191) and in having more widely spaced projections. In overall size it is comparable with *Lundbladispورا brevicula*, but differs from that species in having relatively smaller sculptural processes. The occurrence of the genus in this sample (N.S.150, 420 feet, 2 inches) is of interest, as its horizon is, stratigraphically, the lowest of any of the Rewan assemblages studied, being less than 10 feet above the base of the Formation.

Genus *NEVESISPORITES* de Jersey and Paten, 1964

*Type species: Nevesisporites vallatus* de Jersey and Paten, 1964.

*Nevesisporites limatulus* Playford, 1965

Plate 2, Figure 2

*Figured specimen:* Slide S1598, stage co-ordinates 11.3, 86.2; diameter 35 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 83.1.



*Locality:* D.R.D.13, 107 feet, 8 inches.

*Remarks:* Rewan specimens, assigned to this species, are similar to those previously recorded from the Moolayember Formation (de Jersey and Hamilton, 1967, p. 11) and Clematis Sandstone (de Jersey, 1968, p. 10). Their size range (equatorial diameter, based on 35 measured specimens) is from 25 to 46 microns.

*Distribution:* Triassic of Tiers Formation, Tasmania (Playford, 1965); Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

#### Genus REWANISPORA gen. nov.

*Type species:* *Rewanispora foveolata* sp. nov., described below.

*Diagnosis:* Spores radial, trilete; amb circular, sub-circular or convexly sub-triangular. Exine two-layered; intexine thin, smooth, usually closely attached to exoexine. Exoexine with a well defined cingulum, relatively uniform in thickness. Proximal surface of exoexine smooth or finely sculptured; distal surface with foveolate-vermiculate sculpture.

*Comparison:* The distal sculpture differentiates *Rewanispora* from established cingulate genera, such as *Densosporites* (Berry) Butterworth *et al.*, 1964, *Lycospora* Schopf, Wilson and Bentall *emend.* Potonié and Kremp 1954 and *Stenozonotriletes* (Naumova) Potonié, 1958. In the diagnoses of both *Densosporites* (Butterworth, Jansonius, Smith and Staplin, in Staplin and Jansonius, 1964, p. 101) and *Lycospora* (Potonié and Kremp, 1954, p. 156) varied positive sculpture is included, but no provision is made for negative sculpture (foveolae or vermiculae). Furthermore the cingulum in both genera is characteristically cuneiform (wedge-shaped in polar view) in contrast to the uniformly thick cingulum of *Rewanispora*. These features also enable distinction from the cingulate genera *Cristatisporites* (Potonié and Kremp) Butterworth *et al.*, 1964 and *Cingulizonates* (Dybová and Jachowicz) Butterworth *et al.*, 1964.

In the possession of a cingulum of uniform thickness *Rewanispora* resembles *Stenozonotriletes* (Naumova) Potonié, 1958. (Hacquebard (1957, p. 313) independently emended Naumova's definition of *Stenozonotriletes* but did not name a type). However, the presence of distinctive sculpture excludes the Rewan spores from Potonié's definition of *Stenozonotriletes* (Potonié, 1958, p. 25) which restricts that genus to spores with smooth or chagrenate exines. An additional difference between *Stenozonotriletes* and *Rewanispora* is the presence of an intexine in the latter; no evidence for the presence of an inner layer has been recorded in descriptions of any species of *Stenozonotriletes* in the available literature.

*Rewanispora foveolata* sp. nov.

Plate 3, Figures 6, 7, 8, 9 and 10

*Diagnosis:* Spores radial, trilete, planoconvex to bi-convex with strongly arched distal surface. Amb sub-circular or convexly sub-triangular; equatorial diameter (based on 33 measured specimens) 33 to 61 microns;

polar diameter (1 specimen) 23 microns. Laesurae distinct to ill-defined, straight or slightly curved, where evident extending to, or almost to, the equator. Exine two-layered; intexine thin, smooth, usually closely attached to exoexine. Exoexine with a dense cingulum, dark in colour, relatively uniform in thickness, about 3 to 8 microns in width in polar view. Proximal surface of exoexine smooth, distal surface with foveolate-vermiculate (dominantly foveolate) sculpture. Distal sculpture composed of shallow sub-circular or sub-oval pits (foveolae), about 1 to 2 microns in diameter, 1 to 3 microns apart, with a smaller proportion of channels (vermiculae), of variable length, breadth about 1 to 2 microns. Relative proportions of foveolae and vermiculae variable in different specimens; distal sculpture may extend on to distal surface of cingulum.

*Holotype* (Plate 3, Figures 6, 7—proximal, distal foci): Slide S1768, stage co-ordinates 13.6, 95.0; equatorial diameter 40 microns. Co-ordinates of lower right hand corner of cover glass 26.4, 82.8.

*Locality:* D.R.D.18, 152 feet, 7 inches.

*Figured specimen* (Plate 3, Figure 8—distal focus): Slide S1742, stage co-ordinates 6.4, 95.0; equatorial diameter 56 microns. Co-ordinates of lower right hand corner of cover glass 27.1, 83.3.

*Locality:* D.R.D.17, 235 feet, 3 inches.

*Figured specimen* (Plate 3, Figure 9—oblique equatorial view): Slide S1773, stage co-ordinates 13.9, 85.6; equatorial diameter 33 microns; polar diameter 23 microns. Co-ordinates of lower right hand corner of cover glass 27.6, 82.5.

*Locality:* D.R.D.18, 119 feet, 1 inch.

*Figured specimen* (Plate 3, Figure 10—median focus): Slide S1764, stage co-ordinates 14.1, 92.0; equatorial diameter 48 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 85.0.

*Locality:* D.R.D.17, 203 feet, 5 inches.

*Remarks:* The specimens figured illustrate the range of variation in this species. The holotype (Plate 3, Figures 6 and 7) exhibits the characteristically smooth proximal exine and distal foveolate-vermiculate sculpture and has well defined laesurae. Another specimen (Plate 3, Figure 8) has slightly larger pits and an open trilete rent. The strongly arched nature of the distal exine is illustrated by an obliquely compressed specimen (Plate 3, Figure 9). In most specimens the exoexine and intexine are so closely attached that the latter is difficult to detect; a specimen in which it has become detached and thus clearly evident is illustrated in Plate 3, Figure 10. The specific name refers to the distinctive foveolate sculptural elements.

*Distribution:* Lower Rewan Formation (this paper).

Turma MONOLETES Ibrahim, 1933

Subturma AZONOMONOLETES Lubert, 1935

Infraturma SCULPTATOMONOLETI Dybová and Jachowicz, 1957



Genus *ARATRISPORITES* Leschik *emend.* Playford and Dettmann, 1965

*Type species: Aratrisporites parvispinosus* Leschik *emend.* Playford, 1965.

*Aratrisporites* sp. cf. *A. banksi* Playford, 1965

Plate 3, Figure 3

*Figured specimen:* Slide S1591, stage co-ordinates 22.5, 95.1; overall equatorial dimensions  $69 \times 48$  microns; inner layer  $49 \times 33$  microns. Co-ordinates of lower right hand corner of cover glass 26.4, 83.8.

*Locality:* D.R.D.13, 158 feet, 4 inches.

*Remarks:* The specimen figured resembles *A. banksi* Playford (Playford, 1965, pp. 194, 195) in overall size and laesurate characters and, like that species, has sculpture composed of rugulate and conate elements. However, the rugulae do not clearly constitute a *reticulum imperfectum*, as in the Tasmanian specimens of *A. banksi*; for this reason this Rewan specimen is compared, rather than identified, with Playford's species. It is the only specimen, comparable with *A. banksi*, observed in the Rewan assemblages.

*Distribution of A. banksi:* Tiers Formation of Tasmania (Playford, 1965).

*Aratrisporites* sp. cf. *A. parvispinosus*

Leschik *emend.* Playford, 1965

Plate 4, Figures 4, 5, 6 and 7

*Description (based on Rewan specimens):* Spores mono-lete, bilateral; planoconvex to biconvex with strongly arched distal surface. Amb elliptical; overall equatorial diameters (based on 12 measured specimens) length 48 to 56 microns, breadth 38 to 58 microns. Equatorial diameters of inner layer—length 33 to 40 microns, breadth 25 to 30 microns. Laesura curved, usually well defined, extending beyond inner layer, often to equator; about 3 microns in overall width, accompanied by distinct elevated lips, formed by extensions of proximal sculptine. Spore wall (sclerine) two-layered; sculptine (outer layer) proximally attached to, but otherwise loosely enveloping the inner layer. Inner layer thin, smooth, homogeneous, distinct to ill-defined. Sculptine about 1 micron thick, structured, having finely patterned surface bearing simple, delicate spinae that usually taper rapidly from broad sub-circular bases. Spinae about 1.5 to 3 microns in length, 2 microns in basal diameter, about 1.5 to 5 microns apart. Spinose sculpture reduced or absent proximally, clearly evident at equator.

*Figured specimen (Plate 4, Figures 4 and 7):* Slide S1534, stage co-ordinates 20.7, 96.8; overall dimensions  $58 \times 46$  microns, inner layer  $40 \times 26$  microns. Co-ordinates of lower right hand corner of cover glass 27.0, 91.5. (Plate 4, Figure 7 is an oil-immersion photograph ( $\times 1500$ ) of spines).

*Locality:* D.R.D.3, 92 feet, 11 inches.

*Figured specimen (Plate 4, Figures 5 and 6):* Slide S1536, stage co-ordinates 17.0, 86.3; overall dimensions  $59 \times 49$  microns, inner layer  $35 \times 26$  microns. Co-ordinates of lower right hand corner of cover glass 25.3, 82.0. (Plate 4,

Figure 6 is an oil-immersion photograph ( $\times 1500$ ) of spines).

*Locality:* D.R.D.3, 92 feet, 11 inches.

*Remarks:* These Rewan spores resemble *A. parvispinosus* in sculpture and laesurate characters and approximate to it in overall size. The expanded bases of the spinae are particularly reminiscent of the Tasmanian specimens of *A. parvispinosus* described by Playford (1965, p. 194). The Rewan specimens, however, differ from Leschik's species in having an inner layer which is generally less distinct and smaller, relative to the overall diameter of the amb. In addition the spinae are slightly smaller than and not so sparsely distributed as in specimens described by Playford (1965, p. 194) although in the latter feature (spacing of the spinae) they show closer resemblance to Leschik's figures (1955, pl. 5, figs. 2, 4). As the Rewan specimens are insufficient to explore variation in these features, they are compared, rather than identified, with *A. parvispinosus*.

*Distribution of A. parvispinosus:* Middle Keuper of Switzerland (Leschik, 1955); Upper Triassic of Tasmania (Playford, 1965).

*Distribution of A. cf. parvispinosus (this paper):* Uppermost Rewan Formation.

*Aratrisporites plicatus* de Jersey and Hamilton, 1967

Plate 4, Figure 11

*Figured specimen:* Slide S1533, stage co-ordinates 16.1, 92.0; overall dimensions  $59 \times 51$  microns. Co-ordinates of lower right hand corner of cover glass 27.0, 81.7.

*Locality:* D.R.D.3, 92 feet, 11 inches.

*Remarks:* Rewan specimens, assigned to this species, are similar in all respects to those previously described from the Moolayember Formation (de Jersey and Hamilton, 1967, p. 13). The species first appears in the uppermost part of the Rewan sequence.

*Distribution:* Lower and Middle Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Upper Rewan Formation (this paper).

*Aratrisporites rugulatus* sp. nov.

Plate 4, Figures 1, 2 and 3

*Diagnosis:* Spores mono-lete, bilateral, plano-convex or biconvex, with convex distal surface; amb elliptical or oval. Overall equatorial dimensions (based on 74 measured specimens); length 28 to 58 microns, breadth 15 to 48 microns. Polar diameter (based on 7 measured specimens); length 40 to 51 microns, breadth 26 to 35 microns. Laesura accompanied by sinuous, slightly elevated lips, about 1.5 to 3 microns in overall width and usually attaining equatorial margin. Two-layered sclerine comprising a thin, homogeneous, apparently smooth inner layer closely attached proximally and equatorially, but separated distally from the outer layer (sculptine). Inner layer relatively large, dimensions approximately equal to those of amb in polar view. Distal surface and equator of sculptine with rugulate-verrucate sculpture; sculptural elements relatively low (about 1.5 microns in height), about 1.5 to 3 microns in width or basal diameter and about 1.5 to 3 microns apart. A gradation is evident from



the verrucate to more pointed (conate) elements. Rugulate elements of variable length and uneven height. Remainder of exine (apart from rugulate-verrucate sculpture) smooth or finely structured.

*Holotype* (Plate 4, Figure 1): Slide S1610, stage co-ordinates 20.7, 97.3; equatorial dimensions: length 56 microns, breadth 48 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 83.0.

*Locality*: D.R.D.14, 306 feet.

*Figured specimen* (Plate 4, Figure 2): Slide S1611, stage co-ordinates 13.7, 89.3; dimensions  $48 \times 35$  microns. Co-ordinates of lower right hand corner of cover glass 26.2, 85.0.

*Locality*: D.R.D.14, 306 feet.

*Figured specimen* (Plate 4, Figure 3): Slide S1619, stage co-ordinates 8.1, 97.7; equatorial dimensions: length 53 microns, breadth 38 microns. Co-ordinates of lower right hand corner cover glass 26.2, 82.2.

*Locality*: D.R.D.14, 282 feet.

*Remarks*: The holotype (Plate 4, Figure 1) illustrates the variation in sculptural elements (from rugulae to verrucae) and also the characteristic close attachment of the two layers. Slight separation of the layers is visible along one side at the equator. In the other specimen figured in polar view (Plate 4, Figure 3) there is no evident separation of the layers; in this, as in many specimens of this species compressed in polar view, the presence of two layers is not readily apparent. On the basis of such specimens assignment to *Aratrisporites* might be questioned, as Playford and Dettmann (1965, p. 151) specified a "loosely enveloping" outer layer. However specimens compressed in lateral view (Plate 4, Figure 2) show that there is appreciable separation of the layers in the distal region; in this respect *A. rugulatus* resembles other species of *Aratrisporites*. Consequently it is regarded as an extreme variant of the genus, in exhibiting close attachment of the layers in the equatorial as well as in the proximal region, and so is assigned to *Aratrisporites* without formal emendation of the diagnosis of Playford and Dettmann (1965, p. 151).

As indicated, *A. rugulatus* differs from other species of *Aratrisporites* in having this distinctive close attachment of inner and outer layers in proximal and equatorial regions. The sculpture is also distinctive. One other Triassic species—*A. banksi* Playford (Playford, 1965, p. 194)—has rugulate sculptural elements, but these constitute a *reticulum imperfectum*, which has not been observed in *A. rugulatus*. Other features in which the species differ are the presence of verrucate elements in *A. rugulatus*, the larger overall size of *A. banksi* and the smaller size, relative to the amb, of the inner layer of the latter species.

Apart from *A. banksi*, rugulate sculpture is not common in species of *Aratrisporites*. The Cretaceous (Albian) species *A. ocellatus* Hedlund and Norris (Hedlund and Norris, 1968, p. 148) has granulate and rugulate sculptural elements, but the latter are relatively short compared with those of *A. rugulatus*. In addition the presence of two layers is clearly evident in the Cretaceous species,

the overall size of which is significantly less than that of the Rewan specimens.

*Distribution*: Upper Rewan Formation (this paper).

*Aratrisporites strigosus* Playford, 1965

Plate 3, Figure 5

*Figured specimen*: Slide S1563, stage co-ordinates 20.7, 99.0; overall equatorial dimensions  $49 \times 44$  microns; inner layer  $35 \times 28$  microns. Co-ordinates of lower right hand corner of cover glass 26.4, 83.5.

*Locality*: D.R.D.13, 33 feet, 9 inches.

*Remarks*: This species is relatively rare in the Rewan assemblages; the specimens observed conform closely to the description and figures of Playford (1965, pp. 195, 196; pl. 10, figs. 6-9). The dimensions of the Rewan specimens (based on 11 measured specimens) are—overall equatorial diameter—length 35 to 54 microns, breadth 16 to 30 microns.

*Distribution*: Tiers and Brady Formations of Tasmania (Playford, 1965); Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); upper Rewan Formation (this paper).

*Aratrisporites tenuispinosus* Playford, 1965

Plate 3, Figure 4

*Figured specimen*: Slide S1558, stage co-ordinates 20.4, 87.5; dimensions  $36 \times 30$  microns. Co-ordinates of lower right hand corner of cover glass 26.9, 84.2.

*Locality*: D.R.D.3, 127 feet, 7 inches.

*Remarks*: Like spores of this species, recorded from the Clematis Sandstone (de Jersey, 1968, p. 11), the Rewan specimens are generally somewhat smaller than the Tasmanian spores described by Playford (1965, p. 196). On the basis of 55 measured specimens, the overall dimensions (exclusive of spines) of the Rewan specimens are—length, 25 to 44 microns and breadth, 16 to 36 microns. These measurements thus support the evidence from the Clematis assemblages, in extending the known size range of the species.

*Distribution*: Triassic of Tiers Formation, Tasmania (Playford, 1965); basal Clematis Sandstone (de Jersey, 1968, p. 11); uppermost Rewan Formation (this paper).

*Aratrisporites wollariensis* Helby, 1967

Plate 4, Figures 8, 9, 10, 12 and 13.

*Synonyms*: *Aratrisporites* sp. cf. *A. rotundus* Mädlar, 1964; de Jersey and Hamilton, 1967, pp. 12, 13, pl. 6, figs. 13, 14 and 15.

*Aratrisporites* sp. cf. *A. rotundus* Mädlar, 1964; de Jersey, 1968, p. 11, pl. 5, fig. 8.

*Description (based on Rewan specimens)*: Spores monolete, bilateral; planoconvex to biconvex with strongly arched distal surface. Amb elliptical to sub-circular; overall equatorial diameter (based on 100 measured specimens): length 20 to 46 microns, breadth 16 to 38 microns. Laesura straight, length conformable with major axis of spore, with undulating lips which comprise elevated (1 to 2 microns high) extensions of proximal sculptine. Sclerine two-layered, consisting of a thin



homogeneous inner layer (length in polar view 20 to 36 microns, breadth 13 to 26 microns), loosely enveloped within, and proximally attached to, a structured sculptine. Sculptine 1 micron or less in thickness, with fine sculpture consisting of coni, grana and spinae. Sculptural elements about 0.5 to 1.5 microns in height, 0.5 to 1 micron in basal diameter, about 1 micron apart. Sculptural elements showing variation in size and shape within each specimen and from one specimen to another.

*Figured specimen* (Plate 4, Figure 8): Slide S1643, stage co-ordinates 14.1, 96.7; overall equatorial dimensions  $36 \times 30$  microns. Co-ordinates of lower right hand corner of cover glass 26.4, 84.0.

*Locality*: D.R.D.14, 145 feet, 6 inches.

*Figured specimen* (Plate 4, Figure 9): Slide S1623, stage co-ordinates 15.1, 93.4; overall equatorial dimensions  $31 \times 23$  microns. Co-ordinates of lower right hand corner of cover glass 26.6, 84.6.

*Locality*: D.R.D.14, 294 feet, 8 inches.

*Figured specimen* (Plate 4, Figure 10): Slide S1640, stage co-ordinates 15.1, 90.6; overall equatorial dimensions  $40 \times 30$  microns. Co-ordinates of lower right hand corner of cover glass 27.0, 85.3.

*Locality*: D.R.D.14, 145 feet, 6 inches.

*Figured specimen* (Plate 4, Figure 12): Slide S1558, stage co-ordinates 16.9, 93.5; overall equatorial dimensions  $33 \times 23$  microns. Co-ordinates of lower right hand corner of cover glass 26.9, 84.2.

*Locality*: D.R.D.3, 127 feet, 7 inches.

*Figured specimen* (Plate 4, Figure 13): Slide S1536, stage co-ordinates 20.0, 95.3; overall equatorial dimensions  $30 \times 21$  microns. Co-ordinates of lower right hand corner of cover glass 25.2, 92.1.

*Locality*: D.R.D.3, 92 feet, 11 inches.

*Remarks*: In previous papers (de Jersey and Hamilton, 1967; de Jersey, 1968), specimens recorded as *Aratrisporites* sp. cf. *A. rotundus* Mädlar were regarded provisionally as distinct from *A. wollariensis* Helby. Although spores recorded separately under these names are similar in overall size, equatorial outline and sculptural characters, specimens recorded as *A. wollariensis* were provisionally distinguished on the basis of folding at the margin of the inner layer, which thins noticeably in the vicinity of the laesura—features noted by Helby (1967, p. 67). However, study of a large number of specimens in the Rewan assemblages shows a complete gradation in these features, from specimens with well defined, unfolded inner layers (typical of those assigned to *A. cf. rotundus*) to those with distinctly folded inner layers. Similar gradation is also evident in the thinning of the inner layer in the vicinity of the laesura. Gradation in these features is illustrated by three of the specimens figured (Plate 4, Figures 8, 9 and 10). Accordingly specimens previously recorded as *Aratrisporites* sp. cf. *A. rotundus* are now regarded as identifiable with *A. wollariensis* Helby.

The Rewan specimens also show variation in the size of the inner layer, relative to the overall dimensions of the amb, and in the size of the sculptural elements. Extreme examples of variation in the relative size of the inner layer are illustrated by Plate 4, Figures 12 and 13; an intermediate specimen is that figured in Plate 4, Figure 9. Variation in the size of the sculptural elements is illustrated by the series (of increasing size) shown by Plate 4, Figures 13, 12 and 8. Continuous variation thus appears to exist in both these characters.

*Distribution*: Wollar Sandstone, Collaroy Claystone and Hawkesbury Sandstone of New South Wales (Helby, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper). The species first appears in the lower part of the Rewan Formation and becomes abundant in the upper part of the sequence.

Genus POLYPODIISPORITES Potonié and  
Gelletich ex Potonié, 1956

*Type species*: *Polypodiisporites favus* (Potonié) Potonié and Gelletich, 1933.

Plate 4, Figure 14

*Figured specimen*: Slide S1623, stage co-ordinates 18.1, 95.0; dimensions  $26 \times 25$  microns. Co-ordinates of lower right hand corner of cover glass 26.8, 84.6.

*Locality*: D.R.D.14, 294 feet, 7 inches.

*Remarks*: This species has been recorded from horizons distributed through the thickness of the Rewan Formation. It is evidently long-ranged in the Triassic of Australia, having been observed in assemblages of Lower, Middle and Upper Triassic age.

*Distribution*: Triassic of Ipswich Coal Measures (de Jersey, 1962); Upper Triassic of Bundamba Group (de Jersey, 1964); Triassic of Moorooka and Tingalpa Formations, Brisbane area (de Jersey and Hamilton, 1965); Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Lower Triassic of Ross Formation, Tasmania (Playford, 1965); Triassic of Wollar Sandstone, New South Wales (Helby, 1967); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

Anteturma POLLENITES Potonié, 1931

Turma SACCITES Erdtman, 1947

Subturma MONOSACCITES Chitaley *emend.* Potonié and Kremp, 1954

Infraturma TRILETESACCITI Leschik, 1955

Subinfraturma INTRORNATI Butterworth and Williams, 1958

Genus GUTHOERLISPORITES Bharadwaj, 1954

*Type species*: *Guthoerlisporites magnificus* Bharadwaj, 1954

*Guthoerlisporites cancellosus* Playford and Dettmann, 1965

Plate 5, Figure 3



*Figured specimen:* Slide S1773, stage co-ordinates 15.4, 100.0; overall equatorial diameter 96 microns. Diameter of intexine 41 microns. Co-ordinates of lower right hand corner of cover glass 27.6, 82.6.

*Locality:* D.R.D.18, 119 feet, 1 inch.

*Remarks:* This species is relatively rare in the assemblages studied.

*Distribution:* Upper Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965); Triassic of Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

*Guthoerlisporites* sp. A.

Plate 5, Figure 4

*Description:* Spores radial, trilete, amb circular or sub-circular. Diameter (based on 6 measured specimens) 58 to 63 microns. Exine two-layered, consisting of a smooth homogeneous intexine, relatively dark in colour, that is distally and equatorially detached from an enveloping finely reticulate exoexine. Diameter of intexine 30 to 33 microns (about half diameter of amb). Reticulum distinct to ill-defined, composed of sub-circular lumina, 1 micron or less in diameter, and narrow muri less than 1 micron wide. Laesurae distinct to ill-defined, length about half radius of intexine.

*Figured specimen:* Slide S1647, stage co-ordinates 16.6, 102.0; overall equatorial diameter 63 microns. Diameter of intexine 30 microns. Co-ordinates of lower right hand corner of cover glass 26.1, 84.5.

*Locality:* D.R.D.14, 184 feet.

*Remarks:* Although of similar general construction to *G. cancellatus* Playford and Dettmann, these spores differ from that species in being somewhat smaller, in having relatively shorter laesurae, and in having a less distinct reticulum composed of smaller lumina which are sub-circular, rather than hexagonal in shape. Insufficient specimens have been observed to warrant formal specific designation.

*Distribution:* Rewan Formation (this paper)

Subturma DISACCITES Cookson, 1947

Genus ALISPORITES Daugherty, 1941

*Type species:* *Alisporites opii* Daugherty, 1941.

*Alisporites australis* de Jersey, 1962

Plate 5, Figure 9.

*Figured specimen:* Slide S1633, stage co-ordinates 23.0, 90.7; total span 69 microns. Co-ordinates of lower right hand corner of cover glass 25.9, 93.4.

*Locality:* D.R.D.14, 195 feet, 10 inches.

*Remarks:* The specimen figured exhibits the well defined colpus which is a characteristic feature of this species.

*Distribution:* Triassic of Ipswich Coal Measures (de Jersey, 1962); Upper Triassic of Bundamba Group (de Jersey, 1964); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965);

Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Jurassic of Precipice Sandstone, Evergreen Formation, and Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

*Alisporites townrovi* Helby, 1967

Plate 5, Figure 10.

*Figured specimen:* Slide S1515, stage co-ordinates 9.0, 93.5; total span 73 microns. Co-ordinates of lower right hand corner of cover glass 27.0, 83.6.

*Locality:* D.R.D.16, 526 feet.

*Remarks:* This species occurs sporadically in the middle and upper part of the Rewan Formation.

*Distribution:* Wollar Sandstone of New South Wales (Helby, 1967); lower Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

Genus KLAUSIPOLLENITES Jansonius, 1962

*Type species:* *Klausipollenites schaubergeri* (Potonié and Klaus) Jansonius, 1962.

*Klausipollenites staplinii* Jansonius, 1962

Plate 5, Figures 5 and 6

*Description (based on Rewan specimens):* Bisaccate pollen grains, attachment of sacchi haploxytonoid. overall outline oval or suboval. Total span (based on 47 measured specimens) 18 to 46 microns. Outline of corpus sub-circular or oval with longer axis in direction of total span or grain. Length of corpus (at right angles to total span) 10 to 30 microns, breadth 15 to 31 microns. Corpus with relatively thin exine, distally smooth, proximally with fine faint infra-reticulum. Sacchi crescent-shaped, relatively narrow compared with longer axis of corpus; length (at right angles to total span of grain) 10 to 30 microns, width 5 to 16 microns. Sacchi attached proximally near equator, distally to a darker area (?-fold). Exine of sacchi of same thickness as, or slightly darker than, that of corpus. Saccus reticulum relatively fine with lumina 1 to 1.5 microns.

*Figured specimen (Plate 5, Figure 5):* Slide S1612, stage co-ordinates 7.0, 87.1; total span 44 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 82.6.

*Locality:* D.R.D.14, 306 feet.

*Figured specimen (Plate 5, Figure 6):* Slide S1585, stage co-ordinates 9.1, 95.0; total span 38 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 85.0.

*Locality:* D.R.D.13, 172 feet, 6 inches.

*Remarks:* The Rewan specimens are similar to those described from the Triassic of Canada by Jansonius (1962, p. 56), one of the figured specimens (Plate 5, Figure 5) showing a close resemblance to the holotype (Jansonius, 1962, pl. 12, fig. 21). There is continuous gradation, in the Rewan material, to specimens below the size range given by that author; the greater variation in size of the Queensland specimens is thus considered



significant only in extending the known size range of the species.

A feature not indicated in the original diagnosis is the tendency for the corpus to be elongated in the direction of the total span of the grain (e.g. Plate 5, Figure 6). However this is evident from illustrations of the type material, e.g. Jansonius (1962, pl. 12, fig. 27). This feature was rightly emphasised by Klaus (1963, p. 333) in his restatement of the generic diagnosis. The genus can thus be distinguished from *Vesicaspora* Schemel, 1951, in which the elongation of the corpus tends to be at right angles to this direction (Klaus, 1963, p. 343).

*Distribution:* Lower Triassic of Western Canada, Upper Permian (Zechstein) of Germany, Lower Permian of Tanganyika (Jansonius, 1962); Rewan Formation (this paper).

Genus *PLATYSACCUS* Naumova ex  
Potonié and Klaus, 1954

*Type species:* *Platysaccus papilionis* Potonié and Klaus, 1954.

*Platysaccus queenslandi* de Jersey, 1962  
Plate 6, Figures 2 and 3

*Figured specimen* (Plate 6, Figure 2): Slide S1649, stage co-ordinates 8.2, 94.0; total span 91 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 83.7.

*Locality:* D.R.D.14, 115 feet, 10 inches.

*Figured specimen* (Plate 6, Figure 3): Slide S1565, stage co-ordinates 13.8, 100.7; total span 74 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 85.1.

*Locality:* D.R.D.13, 33 feet, 9 inches.

*Remarks:* This species is widely distributed in the Rewan assemblages. In many specimens, for example, that figured in Plate 6, Figure 2, the corpus has a broadly oval outline, being elongated in the direction of the total span of the grain. Although the outline of the corpus was described as "sub-circular" in the original diagnosis (de Jersey, 1962, p. 10), many of the specimens on which the original study was based, including the holotype (de Jersey, 1962, pl. 4, fig. 5), show some elongation of the corpus in the direction of the overall length of the grain. Consequently specimens such as that figured in Plate 6, Figure 2 of this paper are regarded as extreme examples of variation in the outline of the corpus (from circular to broadly ovate). The Rewan specimens also show appreciable variation in size, the total span (based on 50 measured specimens) ranging from 46 to 92 microns.

*Distribution:* Triassic of Ipswich Coal Measures (de Jersey, 1962); Upper Triassic of Bundamba Group (de Jersey, 1964); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

Genus *SULCATISPORITES* Leschik *emend.*  
Mädler, 1964

*Type species:* *Sulcatisporites interpositus* Leschik, 1955.

*Sulcatisporites* sp. cf. *S. kraeuseli*  
Mädler, 1964

Plate 5, Figure 2

*Figured specimen:* Slide S1534, stage co-ordinates 17.5, 100.3; total span 54 microns. Co-ordinates of lower right hand corner of cover glass 27.0, 81.6.

*Locality:* D.R.D.3, 92 feet, 11 inches.

*Remarks:* The specimen figured is representative of grains which resemble *S. kraeuseli* Mädler in general morphology and particularly in having the distinctive fine saccus reticulum (Mädler, 1964, p. 65). They differ from the European species, however, in being appreciably smaller. The total span (breadth) of the grain, based on 13 measured specimens, is from 53 to 76 microns, for the Rewan specimens, while the size range quoted for Mädler's species is from 75 to 90 microns. As the number of specimens measured is inadequate for size comparison of these bisaccate grains the Rewan specimens are compared, rather than identified, with *Sulcatisporites kraeuseli*.

*Distribution of Sulcatisporites* sp. cf. *S. kraeuseli:* Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

*Distribution of Sulcatisporites kraeuseli:* Upper Bunter Sandstone, lower Muschelkalk and lower Keuper of Germany (Mädler, 1964; Schulz, 1966).

*Sulcatisporites ovatus* (Balme and Hennelly)  
Bharadwaj, 1962  
Plate 5, Figure 1

*Figured specimen:* Slide S1787, stage co-ordinates 17.6, 93.7; total span 56 microns. Co-ordinates of lower right hand corner of cover glass 28.0, 84.7.

*Locality:* D.R.D.19, 118 feet.

*Remarks:* This species, which is common in Australian Permian microfloras, survives in rare proportions into the basal part of the Rewan Formation.

*Distribution:* Permian of Australia (Balme and Hennelly, 1955); Permian of India (Bharadwaj, 1962); Permian of Antarctica (Balme and Playford, 1967); basal Rewan Formation (this paper).

Genus *SULCOSACCISPORA* Klaus, 1964

*Sulcosaccispora alaticonformis* (Malyavkina)  
de Jersey, 1968  
Plate 5, Figure 8

*Figured specimen:* Slide S1602, stage co-ordinates 22.0, 93.2; dimensions 33 × 23 microns. Co-ordinates of lower right hand corner of cover glass 27.0, 83.7.



*Locality:* D.R.D.13, 82 feet, 7 inches.

*Remarks:* This species is a rare component of assemblages from the upper part of the Rewan Formation.

*Distribution:* Lower and Middle Triassic of U.S.S.R. (Malyavkina, 1964); Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

Genus TRIADISPORA Klaus, 1964

*Type species:* *Triadispora plicata* Klaus, 1964.

*Remarks:* In the writer's previous discussion of *Triadispora* and comparable genera (de Jersey, 1968, pp. 15, 16), reference to *Pseudillinites* Mädlér, 1964 was omitted. From its description and data of publication (June 15th, 1964) this genus is regarded as a junior synonym of *Triadispora*.

*Triadispora crassa* Klaus, 1964

Plate 6, Figure 1

*Figured specimen:* Slide S1449, stage co-ordinates 7.2, 84.4; total span 63 microns. Co-ordinates of lower right hand corner of cover glass 27.4, 83.0.

*Locality:* D.R.D.3, 70 feet, 8 inches.

*Remarks:* Visscher (1966) has given a comprehensive, well illustrated account of the morphology of this rather variable species. From this account it is clear that specimens recorded from the Rewan Formation and Clematis Sandstone fall within the range of variation of *T. crassa*. The specimen figured (Plate 6, Figure 1) illustrates the transition to the platysaccoid condition and is comparable with a specimen of a platysaccoid variant figured by Visscher (1966, pl. 10, fig. 4).

*Distribution:* Upper Bunter Sandstone of France (Klaus, 1964); upper Bunter Sandstone and lower Muschelkalk of the Netherlands (Visscher, 1966; Visscher and Commissaris, 1968); upper Bunter Sandstone of East Germany (Schulz, 1966); Carnian of Austria (Kavary, 1966); lower Clematis Sandstone (de Jersey, 1968); upper Rewan Formation (this paper).

Genus VITREISPORITES Leschik *emend.*

Jansonius, 1962

*Type species:* *Vitreisporites signatus* Leschik, 1955

*Vitreisporites pallidus* (Reissinger) Nilsson, 1958

Plate 5, Figure 7

*Figured specimen:* Slide S1742, stage co-ordinates 14.8, 89.5; total span 28 microns. Co-ordinates of lower right hand corner of cover glass 27.0, 82.2.

*Locality:* D.R.D.17, 235 feet, 3 inches.

*Remarks:* This species is a rare, but fairly persistent component of the Rewan assemblages. It has also been observed in the underlying Upper Permian coal measures. The size range (total span, based on 13 measured specimens) is from 20 to 38 microns.

*Distribution:* Widely distributed in the Jurassic of Europe and North America; Permian, Triassic, and Jurassic of Madagascar (Goubin, 1965). Upper Permian, Lower Triassic and Jurassic, and Lower Cretaceous of Western Australia (Balme, 1957, 1963); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Jurassic of Surat Basin, Queensland (de Jersey and Paten, 1964); Jurassic of Walloon Coal Measures and Marburg Sandstone (de Jersey, 1959, 1963); Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

Genus VOLTZIAEAE SPORITES Klaus, 1964

*Type species:* *Voltziaceasporites heteromorpha* Klaus, 1964.

*Voltziaceasporites heteromorpha* Klaus, 1964

Plate 6, Figures 4, 5, 6, 7 and 8

*Description (based on Rewan specimens):* Monosaccate, intexine partially enclosed in a saccus which is inflated in two opposite portions, simulating the bisaccate condition. Total span (based on 49 measured specimens) 50 to 102 microns. Exoexine absent over distal germinal area, exposed condition visible in laterally compressed specimens. Intexine smooth, alete, outline sub-circular to broadly oval; mean diameter in polar view 23 to 44 microns. Exoexine with a fine indistinct internal reticulum; lumina of reticulum about 1 micron in diameter. In polar view cappa may exhibit indistinct folds, oriented parallel to the longer axis of the grain.

*Figured specimen (Plate 6, Figure 4—polar view):* Slide S1704, stage co-ordinates 14.5, 86.9; total span 73 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 83.0.

*Locality:* D.R.D.15, 107 feet, 9 inches.

*Figured specimen (Plate 6, Figure 5—polar view):* Slide S1738, stage co-ordinates 22.0, 101.9; total span 79 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 84.1.

*Locality:* D.R.D.17, 234 feet, 11 inches.

*Figured specimen (Plate 6, Figure 6—polar view):* Slide S1622, stage co-ordinates 9.0, 87.8; total span 76 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 83.2.

*Locality:* D.R.D.14, 282 feet.

*Figured specimen (Plate 6, Figure 7—lateral view):* Slide S1623, stage co-ordinates 23.0, 95.0; total span 63 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 84.5.

*Locality:* D.R.D.14, 294 feet, 7 inches.

*Figured specimen (Plate 6, Figure 8—lateral view):* Slide S1613, stage co-ordinates 7.5, 84.6; total span 76 microns. Co-ordinates of lower right hand corner of cover glass 26.0, 81.7.

*Locality:* D.R.D.14, 306 feet.



*Remarks:* These grains have all the essential diagnostic features of specimens of the species recorded by Klaus (1964) and Visscher (1966). Measurements of the total span quoted by those authors are: 70 to 150 microns (Klaus, 1964, p. 129) and 70 to 135 microns (Visscher, 1966, p. 342). Some of the Rewan specimens are below the lower limit of these size ranges, but this is considered significant only as regards extending the known size range of this rather variable species. As in European examples of the species, the saccus shape is also subject to variation. This variation is expressed by gradation from a markedly reduced saccus, through intermediate "haploxylonoid" shapes, to the expanded ("platysacoid") condition.

*Distribution:* Bunter Sandstone (Lower Triassic) of France and Germany (Klaus, 1964); Middle and Upper Scythian, Anisian and Ladinian of Alpine Triassic (Klaus, 1965); Upper Bunter Sandstone and Muschelkalk of the Netherlands (Visscher, 1966; Visscher and Commissaris, 1968); Middle Bunter Sandstone of Thuringia, Germany (Reinhardt and Schön, 1967); Upper Bunter Sandstone and Muschelkalk of East Germany (Schulz, 1966); lower Clematis Sandstone of Queensland (de Jersey, 1968); middle and upper Rewan Formation (this paper).

Subturma STRIATITES Pant, 1954

Genus HAMIAPOLLENITES Wilson, 1962

*Type species:* *Hamiapollenites saccatus* Wilson, 1962.  
*Hamiapollenites insculptus* Playford and Dettman, 1965

Plate 7, Figure 1

*Figured specimen:* Slide S1550, stage co-ordinates 25.0, 93.1; total span 81 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 80.0.

*Locality:* D.R.D.4, 188 feet, 1 inch.

*Remarks:* The specimen figured is the only one of this species observed in the present study of the Rewan assemblages. The species is evidently a rare component of the microflora and, in the material examined, is confined to the uppermost part of the Rewan sequence.

*Distribution:* Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Ipswich Coal Measures (Hill, Playford and Woods, 1965); lower Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); uppermost Rewan Formation (this paper.)

Genus LUECKISPORITES Potonie and Klaus *emend.*  
Klaus, 1963

*Type species:* *Lueckisporites virkkiae* Potonié and Klaus *emend.* Klaus, 1963.

*Lueckisporites* sp. cf. *L. tattooensis* Jansonius 1962  
Plate 7, Figure 5

*Figured specimen:* Slide S1444, stage co-ordinates 18.4, 98.5; total span 73 microns; dimensions of corpus 41 × 46 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 84.3.

*Locality:* D.R.D.4, 163 feet, 2 inches.

*Remarks:* The specimen figured resembles *L. tattooensis* (Jansonius, 1962, p. 61) in overall dimensions and particularly in the elongation of the corpus in the direction of the total span of the grain. However, it differs from the illustration of that species (Jansonius, 1962, pl. 13, fig. 8) in having taeniae which are appreciably darker than the sacchi. For this reason and because it is the only specimen of this type observed, it is compared, rather than identified, with the Canadian species.

The assignment of this Rewan specimen and of *L. tattooensis* to *Lueckisporites*, as circumscribed by Klaus (1963, p. 299), should be regarded as provisional, pending study of further material. This is because the generic diagnosis of Klaus specified the presence of a monolete intexinal mark as an essential requirement. This feature has not been observed in either the Rewan specimen or *L. tattooensis*; however it cannot be assumed to be absent in either the Queensland or Canadian material until sufficient well preserved specimens have been studied.

*Distribution of L. tattooensis:* Lower Triassic of Western Canada (Jansonius, 1962); Upper Permian and Lower Triassic of Central Europe (Klaus, 1965).

Genus PROTOHAPLOXYPINUS Samoilovich  
*emend.* Hart, 1964

*Type species:* *Protohaploxypinus latissimus* (Luber) Samoilovich.

*Protohaploxypinus limpidus* (Balme and Hennelly)  
Balme and Playford, 1967.

Plate 8, Figure 5

*Figured specimen:* Slide S1798, stage co-ordinates 10.0, 93.4; total span 56 microns. Co-ordinates of lower right hand corner of cover glass 27.9, 83.4.

*Locality:* N.S.12 (Theodore), 210 feet, 3 inches. (Baralaba Coal Measures).

*Remarks:* The writer is in agreement with the taxonomic treatment of this species by Balme and Playford (1967, p. 185); reference should be made to that paper for a discussion of its synonymy. In the present study it has been recorded mainly from the basal part of the Rewan Formation and the underlying Baralaba Coal Measures. It is suspected that occurrences at higher horizons represent recycled specimens.

*Distribution:* Widely distributed in the Permian of Australia (Balme and Hennelly, 1955); Permian of India, South America (Hart, 1964); Permian of Antarctica (Balme and Playford, 1967); Rewan Formation, uppermost Baralaba Coal Measures (this paper).

*Protohaploxypinus samoilovichii* (Jansonius)  
Hart, 1964  
Plate 7, Figure 6

*Figured specimen:* Slide S1695, stage co-ordinates 7.3, 100.3; total span 68 microns; corpus 46 × 40 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 84.5.



*Locality:* D.R.D.15, 108 feet, 6 inches.

*Remarks:* The specimens recorded here conform to the original diagnosis of Jansonius (1962, p. 67) and are also similar to specimens described by Playford (1965, p. 198) from the Triassic of Tasmania. The dimensions of the Rewan specimens (based on 20 measured specimens) are—total span, 53 to 87 microns; length of corpus, 30 to 56 microns; breadth of corpus, 28 to 53 microns; distal zone (cappula), 7 to 20 microns; length of saccus, 36 to 53 microns; breadth of saccus, 23 to 33 microns.

*Distribution:* Lower Triassic of Western Canada (Jansonius, 1962); Zechstein and Bunter Sandstone of East Germany (Schulz, 1966); Triassic of Tasmania (Playford, 1965); Rewan Formation (this paper).

Genus *STRIATISACCUS* Mädlar *emend.*

Reinhardt and Schön, 1967

*Type species:* *Striatissaccus goswicensis* Mädlar, 1964.

*Diagnosis:* As given for *Taeniaesporites* by Klaus (1963, p. 306).

*Remarks:* Reinhardt and Schön (1967, p. 754) have emended the generic diagnosis of *Striatissaccus* Mädlar (1964, pp. 56, 57), the emended diagnosis being that given for *Taeniaesporites* by Klaus (1963, p. 306). The writer is in agreement with this emendation; *Striatissaccus* as thus circumscribed provides a suitable repository for certain species previously assigned to *Taeniaesporites*. Reasons for the transference to *Striatissaccus* of the species concerned have been discussed by Visscher (1966, pp. 357, 358), Reinhardt and Schön (1967, pp. 754, 755), and by the writer (de Jersey, 1968, p. 18). Well preserved specimens of *Striatissaccus* from the Rewan Formation show clearly the monolete mark on the intexine, which is a characteristic feature of the genus, and one of the characteristics by which it can be distinguished from *Lunatisporites* Leschik *emend.* Bharadwaj, 1962, which has an alele intexine.

*Striatissaccus novimundi* (Jansonius) de Jersey,  
1968

Plate 7, Figures 3 and 4

*Description (based on Rewan specimens):* Bisaccate pollen grains, amb slightly diploxyloid to almost haploxyloid. Total span (based on 33 measured specimens) 51 to 91 microns. Well defined corpus, circular to oval (slight longitudinal or transverse elongation) in polar view. Length of corpus (at right angles to total span of grain): 30 to 59 microns, breadth of corpus 30 to 56 microns. Proximal face of corpus with four thickened bands (taeniae) about 5 to 8 microns wide, the inner ones usually strongly inflated, with a fine indistinct reticulum (lumina less than 1 micron). Distal surface of corpus smooth. Intexine of corpus with monolete mark, centrally located on proximal intexine, parallel to length of grain (discernible on well preserved specimens). Sacchi discrete, approximately semi-circular in shape, breadth half to two-thirds breadth of corpus, reticulum well defined to indistinct, lumina about 1 to 1.5 microns.

Saccus attachment equatorial and distal; distal attachments slightly to distinctly concave, marked by prominent, regular attachment folds. Breadth of cappula (distal zone) 11 to 21 microns (about one quarter to half that of corpus).

*Figured specimen (Plate 7, Figure 3):* Slide S1706, stage co-ordinates 16.0, 101.2; total span 64 microns; corpus 43 × 43 microns. Co-ordinates of lower right hand corner of cover glass 26.0, 85.2.

*Locality:* D.R.D.15, 106 feet, 2 inches.

*Figured specimen (Plate 7, Figure 4):* Slide S1736, stage co-ordinates 18.3, 95.8; total span 96 microns; corpus 36 × 40 microns. Co-ordinates of lower right hand corner of cover glass 27.1, 85.0.

*Locality:* D.R.D.17, 270 feet, 6 inches.

*Remarks:* The Rewan specimens support the writer's assignment of this species to *Striatissaccus* (de Jersey, 1968, p. 18); well preserved examples (e.g. Plate 7, Figure 4) show the monolete intexinal mark, characteristic of the genus. In the same paper (de Jersey, 1968, p. 19) the writer has discussed the distinction between this species and *Taeniaesporites noviaulensis* Leschik, 1956; the Rewan specimens support this distinction.

On the basis of published accounts of the species, difficulty is experienced in assessing the distinction between *S. novimundi* and *S. ovatus* (Goubin) Reinhardt and Schön, 1967. The latter authors (Reinhardt and Schön, 1967, p. 756) based their distinction on the overall outline, regarding the former as diploxyloid and the latter as having an oval, or rarely slightly diploxyloid outline. Detailed examination of published illustrations of these species shows that this criterion is difficult to apply. The holotype of *S. novimundi* (Jansonius, 1962, pl. 13, fig. 19) is only slightly diploxyloid, two other illustrations (pl. 13, figs. 21 and 22) even less so. The holotype of *S. ovatus* (Goubin, 1965, pl. 2, fig. 2) is slightly diploxyloid, the saccus attachment being very similar to that of the holotype of *S. novimundi*, while the other figured specimen (Goubin, 1965, pl. 2, fig. 3) is more diploxyloid than some of the figures of the Canadian species.

Another feature which may appear to afford a means of distinction between these species is the outline of the corpus. In specimens of *S. novimundi* described and figured by Jansonius (1962) the corpus is sub-circular or slightly elongated, parallel to the total span of the grain, while in *S. ovatus* (Goubin, 1965, p. 1423) the corpus is described as "un peu prolate", i.e. slightly elongated in the direction at right angles to the total span of the grain. However the Rewan specimens show a continuous range of variation, from one direction of elongation, through the sub-circular condition to elongation in the other direction. Such variation makes it appear that distinction based on the outline of the corpus may also be inconclusive.

The two species are similar in other features, including the width of the distal zone (cappula)—about one-third the width of the corpus in *S. ovatus* and 20 to 40 per cent of its width in *S. novimundi*. In view of the difficulty of finding any reliable criterion to distinguish them, it is suggested that *S. ovatus* may be a junior synonym of



*S. novimundi*. However, it is not formally recorded as such because of the lack of detailed knowledge of variation in material from the type locality of each species.

Identification of the Rewan specimens with *S. novimundi* is illustrated by the close similarity of the figured specimens to the holotype (Jansonius, 1962, pl. 13, fig. 19); the dimensions of one of them (Plate 7, Figure 4) are closely comparable with those given for a median specimen by Jansonius (1962, p. 63). In the above description of the Rewan specimens, the circumscription of the species has been widened slightly to include specimens with the corpus slightly elongated at right angles to the total span of the grain, as well as those with the corpus elongated in the same direction as the total span (as in specimens described by Jansonius, 1962, p. 63). Variation of the Rewan specimens in this regard is so continuous as to indicate that they are all conspecific. Finally, specimens recorded below as *Striatissaccus* sp. A may represent extreme variants of *S. novimundi*; their relation to that species is discussed below.

**Distribution:** Lower Triassic of Western Canada (Jansonius, 1962); Lower Triassic of Western Australia (Balme, 1963); Bunter Sandstone of Austria and Muschelkalk of Italy, France and Germany (Klaus, 1964); Permian of England (Clarke, 1965b); Lower Keuper of East Germany (Schulz, 1966); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

*Striatissaccus obex* (Balme) Reinhardt and  
Schön, 1967

Plate 7, Figure 8

**Figured specimen:** Slide S1744, stage co-ordinates 11.0, 82.5; total span 76 microns, diameter of corpus 37 microns. Co-ordinates of lower right hand corner of cover glass 28.0, 82.2.

**Locality:** D.R.D.18, 119 feet, 1 inch.

**Remarks:** The transference of this species from *Taeniasporites* by Reinhardt and Schön (1967, p. 756) is supported here. Balme's illustrations (1963, pl. 6, figs. 1-3) show clearly the intexinal mark which is a characteristic feature of *Striatissaccus*. The species can be distinguished from *S. novimundi* by its relatively large diploxylonoid sacchi, darker taeniae and by the circular outline of the corpus. The Rewan specimens conform closely to Balme's diagnosis (1963, p. 29); their total span (based on 13 measured specimens) ranges from 66 to 89 microns, the diameter of the corpus from 30 to 43 microns.

**Distribution:** Lower Triassic of Western Australia (Balme, 1963); Rewan Formation (this paper).

*Striatissaccus* sp. A

Plate 7, Figure 2

**Figured specimen:** Slide S1707, stage co-ordinates 15.8, 100.0; total span 59 microns, dimensions of corpus  $53 \times 43$  microns. Co-ordinates of lower right hand corner of cover glass 27.1, 85.7.

**Locality:** D.R.D.15, 126 feet, 2 inches.

**Remarks:** The specimen figured is typical of a few specimens which differ from grains assigned to *Striatissaccus novimundi* in having a very narrow distal zone (cappula). Insufficient data are available to indicate whether such specimens can be separated as a distinct species, or whether they represent extreme variants of *S. novimundi*.

Another species which shows some resemblance to *Striatissaccus* sp. A is *Striatissaccus austriacus* (Klaus) Reinhardt and Schön, 1967. As figured by Klaus (1964, pl. 4, fig. 44) this species has a narrow distal zone and reduced sacchi, but differs from *Striatissaccus* sp. A in having a corpus which is elongated in the direction of the total span of the grain. It also lacks the thickened folds at the distal bases of the sacchi which are a feature of the Queensland specimens.

**Distribution:** Lower and Middle Rewan Formation (this paper).

#### Genus STRIATOABIETITES Sedova, 1956

**Type species:** *Striatoabietites bricki* Sedova, 1956.  
*Striatoabietites multistriatus* (Balme and Hennelly) Hart, 1964

**Remarks:** Rare specimens of this species have been observed in the Rewan assemblages. From their rarity and sporadic distribution it is suggested that they have been reworked from underlying Permian sediments.

**Distribution:** Permian of Australia (Balme and Hennelly, 1955); Permian of South Africa, South America, India (Hart, 1964); Triassic of Rewan Formation (this paper).

#### Genus STRIATOPODOCARPITES Sedova emend. Hart, 1964

**Type species:** *Striatopodocarpites tojmensis* Sedova, 1956.

*Striatopodocarpites cancellatus* (Balme and Hennelly) Hart, 1963

Plate 7, Figure 7

**Figured specimen:** Slide S1950, stage co-ordinates 11.8, 88.2; total span 68 microns. Co-ordinates of lower right hand corner of cover glass 27.3, 84.6.

**Locality:** N.S. 150, 656 feet, 9 inches. (Baralaba Coal Measures).

**Remarks:** This species is common in microfloras from the Permian of Queensland. A few specimens have been observed in assemblages from the basal part of the Rewan Formation.

**Distribution:** Widely distributed in the Permian of Australia (Balme and Hennelly, 1955); Permian of India (Hart, 1964); Permian of Antarctica (Balme and Playford, 1967); basal Rewan Formation, uppermost Baralaba Coal Measures (this paper).



## Genus STRIOMONOSACCITES Bharadwaj, 1962

Type species: *Striomonosaccites ovatus* Bharadwaj, 1962  
*Striomonosaccites* sp. cf. *S. ovatus* Bharadwaj, 1962

Plate 8, Figures 1, 2, 3 and 4

*Description (based on Rewan specimens):* Monosaccate pollen grains. Corpus in polar view sub-circular or broadly oval, saccus with equatorial or sub-equatorial attachments. Saccus of uneven width, equatorial outline slightly to distinctly lobate. Overall equatorial diameter (based on 20 measured specimens) 48 to 96 microns; diameter of corpus 35 to 56 microns; mean width of saccus about 10 to 20 microns. Proximal exine of corpus with sub-parallel taeniae, about 4 to 6 in number; taeniae with fine reticulum (lumina less than 1 micron). Distal exine of corpus smooth or finely ornamented. Saccus reticulum relatively fine, lumina about 1 micron in diameter, muri about 1 micron in width.

*Figured specimen (Plate 8, Figure 1):* Slide S1613, stage co-ordinates 19.7, 94.9; overall diameter 73 microns, corpus 56 microns.

*Locality:* D.R.D.14, 306 feet.

*Figured specimen (Plate 8, Figure 2):* Slide S1705, stage co-ordinates 15.1, 99.0; overall dimensions  $61 \times 53$  microns, corpus  $49 \times 35$  microns. Co-ordinates of lower right hand corner of cover glass 26.3, 84.6.

*Locality:* D.R.D.15, 106 feet, 2 inches.

*Figured specimen (Plate 8, Figure 3):* Slide S1774, stage co-ordinates 23.4, 100.6; overall dimensions  $71 \times 56$  microns, corpus  $54 \times 50$  microns. Co-ordinates of lower right hand corner of cover glass 28.0, 82.2.

*Locality:* D.R.D.18, 119 feet, 1 inch.

*Figured specimen (Plate 8, Figure 4):* Slide S1768, stage co-ordinates 23.2, 84.6; overall diameter 69 microns, corpus  $41 \times 38$  microns. Co-ordinates of lower right hand corner of cover glass 20.4, 82.7.

*Locality:* D.R.D.18, 152 feet, 7 inches.

*Remarks:* These Rewan specimens are very reminiscent of *Striomonosaccites ovatus* Bharadwaj (Bharadwaj, 1962, p. 88) from the Permian of the Raniganj coalfield, India. Features in which they resemble that species are the number of taeniae and ratio of the diameter of the corpus to the overall diameter. They appear to differ from the Indian species in being appreciably smaller and in the deeper lobing of the saccus. (The latter feature is not mentioned in the description of the Indian species although one of the figures (Bharadwaj, 1962, pl. 7, fig. 109) shows a saccus of uneven width). Because of these differences the Rewan specimens are compared, rather than identified, with *S. ovatus*.

The specimens figured illustrate variation in the Queensland material. Thus the saccus varies from deeply lobed (Plate 8, Figure 3) to almost uniform in width (Plate 8, Figure 2). Considerable variation is also evident in the distinctness of the proximal taeniae. These may be clearly defined (Plate 8, Figures 2 and 3) but in many specimens are poorly preserved (Plate 8, Figure 4). In

some specimens, e.g. that on Plate 8, Figure 1, the proximal exine of the corpus appears to have been completely torn out. In most cases, however, the proximal taeniae are at least faintly discernible.

*Distribution of Striomonosaccites cf. ovatus:* Rewan Formation (this paper).

## Genus VITTATINA Lubert ex Wilson, 1962

*Remarks:* A few poorly preserved grains of this genus, which in most cases are not specifically identifiable, have been observed in the Rewan assemblages.

Turma ALETES Ibrahim, 1933

Subturma AZONALETES Lubert emend. Potonié and Kremp, 1954

Infraturma PSILONAPITI Erdtman, 1947

## Genus GREBESPORA Jansonius, 1962

Type species: *Grebespora concentrica* Jansonius, 1962  
*Grebespora concentrica* Jansonius, 1962  
 Plate 9, Figure 9

*Figured specimen:* Slide S1667, stage co-ordinates 10.2, 101.4; dimensions  $26 \times 21$  microns. Co-ordinates of lower right hand corner of cover glass 26.6, 84.0.

*Locality:* D.R.D.15, 273 feet, 3 inches.

*Remarks:* Specimens of this species are similar to those previously recorded from the Moolayember Formation (de Jersey and Hamilton, 1967, p. 20) and Clematis Sandstone (de Jersey, 1968, p. 20). The range in equatorial diameter of the Rewan specimens (based on 7 measured specimens) is from 20 to 43 microns.

*Distribution:* Lower Triassic of Western Canada (Jansonius, 1962); Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

*Grebespora magna* sp. nov.

Plate 9, Figures 11 and 12

*Diagnosis:* Alete spores or pollen grains; equatorial outline sub-circular or broadly oval. Mean equatorial diameter (based on 39 measured specimens) 43 to 73 microns. One face with a circular fold (about 1.5 to 5 microns in width), concentric with equatorial outline, located about 3 to 5 microns from equatorial margin. Portion of exine enclosed by fold scabrate, slightly darker in colour; remainder of exine thin (1 micron or less), smooth.

*Holotype (Plate 9, Figure 12):* Slide S1610, stage co-ordinates 18.1, 98.0; overall equatorial diameter 53 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 83.0.

*Locality:* D.R.D.14, 306 feet.

*Figured specimen (Plate 9, Figure 11):* Slide S1611, stage co-ordinates 21.9, 100.0; overall equatorial diameter 53 microns. Co-ordinates of lower right hand corner of cover glass 26.2, 85.0.

*Locality:* D.R.D.14, 306 feet.



*Remarks:* The alete character, sub-circular outline, lack of marked sculpture and distinctive circular fold are features which indicate assignment of this species to *Grebespora* Jansonius. *G. magna* differs from *G. concentrica*, the type and only previously described species of the genus, in its size range, as most specimens of the former have a mean equatorial diameter greater than that quoted for *G. concentrica* by Jansonius (1962, p. 83). Also, more significantly, the exine of *G. magna* is differentiated into a scabrate, darker (? thicker) portion enclosed by the concentric fold, which separates it from the smooth outer portion of the exine. Specimens of *G. concentrica* show no such differentiation.

*Distribution:* Upper Rewan Formation (this paper).  
*Grebespora* sp. A  
Plate 8, Figure 6

*Description:* Alete spores or pollen grains; equatorial outline broadly oval. Mean equatorial diameter (based on 6 measured specimens) 58 to 66 microns. One face with a circular fold (about 3 to 5 microns in width), concentric with equatorial outline, located about 3 to 5 microns from equatorial margin. Portion of exine enclosed by fold verrucate to rugulate, with low projections (less than 1 micron in height). Basal diameter of verrucae 2 to 3 microns; rugulae of similar width; sculptural elements 1 to 2 microns apart. Remainder of exine smooth.

*Figured specimen:* Slide S1623, stage co-ordinates 25.0, 92.5; dimensions 68 × 59 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 84.6.

*Locality:* D.R.D.14, 294 feet, 7 inches.

*Remarks:* These specimens resemble *Grebesporamagna*, described above, in size, equatorial outline and in the presence of the characteristic concentric fold. They differ from that species in having a somewhat thicker (darker) exine and more prominent (verrucate-rugulate) sculpture in the central area. The sculptural elements, although more conspicuous than in other species assigned to the genus, are relatively low in height; for this reason the species is provisionally retained in *Grebespora*. Insufficient specimens have been observed to warrant formal specific assignment.

*Distribution:* Upper Rewan Formation (this paper).  
Infraturma CIRCUMPOLLINI Pflug *emend.* Klaus, 1960  
Genus DISCISPORITES Leschik *emend.* de Jersey, 1964

*Type species:* *Discisporites niger* Leschik, 1955  
*Discisporites psilatus* de Jersey, 1964  
Plate 9, Figures 4, 5 and 6

*Description (based on Rewan specimens):* Amb convexly sub-triangular to sub-circular. Equatorial diameter (based on 35 measured specimens) 20 to 36 microns. Trilete; laesurae straight, length about two-thirds radius of amb, may extend almost to equator. Narrow annular region of thinner exine on distal surface (rimula or ring-tenuitas). Diameter of rimula 8 to 20 microns; ratio of diameters of rimula and amb ranges from 0.32:1 to 0.80:1, with a mean of about 0.55:1. Exine smooth, about 1 to 1.5 microns in thickness.

*Figured specimen (Plate 9, Figure 4):* Slide S1707, stage co-ordinates 21.6, 99.5; equatorial diameter 30 microns. Co-ordinates of lower right hand corner of cover glass 27.1, 85.7.

*Locality:* D.R.D.15, 106 feet, 2 inches.

*Figured specimen (Plate 9, Figure 5):* Slide S1704, stage co-ordinates 9.4, 95.0; equatorial diameter 28 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 83.0.

*Locality:* D.R.D.15, 107 feet, 9 inches.

*Figured specimen (Plate 9, Figure 6):* Slide S1725, stage co-ordinates 13.6, 102.8; diameter 21 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 84.0.

*Locality:* D.R.D.17, 272 feet, 4 inches.

*Remarks:* The Rewan specimens conform, in all essential features, to the diagnosis of this species, originally described from the Upper Triassic of the Bundamba Group (de Jersey, 1964, p. 12). The only slight difference apparent is that the diameter of the rimula, in relation to the overall diameter of the amb, tends to be slightly smaller in the Rewan specimens than in those from the Bundamba assemblages. (The ratio of these diameters in the latter ranges from about 0.65:1 to 0.80:1). However, these ratios fall within the range of variation of the Rewan specimens and in view of the wide range of variation in the latter (evident from the above description) no reliable separation can be attempted on this basis.

Variation is also evident in the Rewan specimens in the presence and distinctness of thickened portions of exine adjacent to the laesurae. These thickenings are clearly defined in one of the specimens figured (Plate 9, Figure 6), inconspicuous in another specimen (Plate 9, Figure 5) and completely lacking in the third specimen (Plate 9, Figure 4). From the specimens studied there appears to be continuous gradation between the extremes represented by Plate 9, Figures 4 and 6; consequently no grouping of the specimens on the basis of this feature can be attempted.

*Distribution:* Upper Triassic of Bundamba Group (de Jersey, 1964); Moolayember Formation (de Jersey and Hamilton, 1967); Rewan Formation (this paper).

Turma PLICATES Naumova *emend.* Potonie, 1960  
Subturma PRAECOLPATES Potonie and Kremp, 1954

Genus MARSUPIPOLLENITES Balme and Hennelly, 1956

*Type species:* *Marsupipollenites triradiatus* Balme and Hennelly, 1956.

*Marsupipollenites klausii* sp. nov.  
Plate 9, Figures 1, 2 and 3

*Diagnosis:* Pollen grains, amb broadly oval to sub-circular, longitudinal axis (based on 9 measured specimens) 33 to 48 microns, transverse axis 31 to 43 microns. Distal exine with two prominent sub-parallel folds, about 3 to 7 microns in width, parallel to the longitudinal axis. Folds symmetrically placed, with distance between folds approximately equal to distance between each fold



and equator in transverse direction. Exine smooth or with fine intra-granulate or intra-baculate sculpture, about 1 micron in thickness.

*Holotype* (Plate 9, Figure 3): Slide S1706, stage co-ordinates 12.5, 85.7; dimensions  $40 \times 33$  microns. Co-ordinates of lower right hand corner of cover glass 26.0, 85.1.

*Locality*: D.R.D.15, 106 feet, 2 inches.

*Figured specimen* (Plate 9, Figure 1): Slide S1706, stage co-ordinates 19.1, 104.6; dimensions  $41 \times 41$  microns. Co-ordinates of lower right hand corner of cover glass 26.0, 85.1.

*Locality*: D.R.D.15, 106 feet, 2 inches.

*Figured specimen* (Plate 9, Figure 2): Slide S1706, stage co-ordinates 18.0, 102.9; dimensions  $33 \times 38$  microns. Co-ordinates of lower right hand corner of cover glass 26.0, 85.1.

*Locality*: D.R.D.15, 106 feet, 2 inches.

*Remarks*: This species resembles the type species *M. triradiatus* Balme and Hennelly (Balme and Hennelly, 1956, pp. 60, 61) in having two prominent distal folds delimiting a sulcus (characteristic of the genus), but differs from that species in lacking a trilete mark, in being somewhat smaller in overall size and in having a smooth or finely intrastructured exine (in contrast to the coarser intra-structure of *M. triradiatus*). A Jurassic species, *M. psilatus*, recorded from the Rosewood coal-field (de Jersey, 1959, p. 359) has a smooth exine, but is appreciably larger and has an amb which is much more elongate than that of the Rewan species.

The specimens figured illustrate the range of variation in intra-structure. The holotype (Plate 9, Figure 3) shows the commoner, virtually smooth condition, while one of the other figured specimens (Plate 9, Figure 2—oil immersion photomicrograph) illustrates the fine intra-structure visible in some of the Rewan specimens.

The specific name refers to Professor W. Klaus, Vienna, in recognition of his significant contributions to knowledge of Triassic microfloras.

*Distribution*: Upper Rewan Formation (this paper).

"*Marsupipollenites*" *sinuosus* Balme and  
Hennelly, 1956

Plate 9, Figure 13

*Figured specimen*: Slide S1787, stage co-ordinates 15.4, 101.0; dimensions  $96 \times 36$  microns. Co-ordinates of lower right hand corner of cover glass 28.0, 84.9.

*Locality*: D.R.D.19, 118 feet.

*Remarks*: The generic assignment of this species has been discussed by Balme and Playford (1967, pp. 182, 183). As stated by those authors, assignment to *Marsupipollenites* is inappropriate, as the species lacks a clearly defined sulcus. Morphologically, it seems closest to *Equisetosporites* Daugherty *emend.* Pocock and Jansonius, 1964 or its invalid synonym *Ephedripites* Bolkhovitina. However grains assigned to *Equisetosporites* differ in having a two-layered exine, the outer layer of

which is divided into narrow and regularly spaced parallel ribs separated by clearly defined grooves (Pocock, 1964, pp. 144, 145).

Consequently, while the current assignment of the species to *Marsupipollenites* should be regarded as provisional, there appears to be no other valid genus available for its reception. It seems possible that proposal of a new genus may be warranted for grains of this type, but such a course is considered beyond the scope of this paper, as it would be preferable for such a taxonomic innovation to be based on Permian, rather than Triassic material.

From the aspect of stratigraphic distribution, "*M. sinuosus*" is a widespread species in the Permian of Australia, but persists only into the basal part of the Rewan Formation. In overall size the Rewan specimens are comparable with those recorded from the Permian (Balme and Hennelly, 1956, p. 61); their length (based on 16 measured specimens) ranges from 68 to 115 microns and their breadth from 25 to 46 microns.

*Distribution*: Permian of Australia (Balme and Hennelly, 1956); Permian of India (Bharadwaj, 1962); Permian of Antarctica (Balme and Playford, 1967); basal Rewan Formation (this paper).

*Marsupipollenites triradiatus* Balme and  
Hennelly, 1956

Plate 9, Figure 10

*Figured specimen*: Slide S2071, stage co-ordinates 19.6, 103.9; dimensions  $46 \times 31$  microns. Co-ordinates of lower right hand corner of cover glass 25.8, 84.8.

*Locality*: D.R.D.28, 293 feet, 10 inches.

*Remarks*: Rare specimens of this species (common in Australian Permian microfloras) have been observed in assemblages from the basal part of the Rewan sequence.

*Distribution*: Permian of Australia (Balme and Hennelly, 1956); Permian of Antarctica (Balme and Playford, 1967); basal Rewan Formation (this paper).

Subturma POLYPLICATES Erdtman, 1952

Genus EQUITETOSPORITES Daugherty *emend.* Pocock and Jansonius, 1964

*Type species*: *Equisetosporites chinleana* Daugherty, 1941.

*Equisetosporites steevesi* (Jansonius) de Jersey, 1968  
Plate 9, Figure 7

*Figured specimen*: Slide S1623, stage co-ordinates 23.1, 94.5; dimensions  $54 \times 33$  microns. Co-ordinates of lower right hand corner of cover glass 26.8, 84.6.

*Locality*: D.R.D.14, 294 feet, 7 inches.

*Remarks*: Two specimens, assigned to this species, have been observed in the Rewan assemblages. Both were derived from the same sample.



*Distribution:* Lower Triassic of Western Canada (Jansonius, 1962); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Upper Rewan Formation (this paper).

Subturma MONOCOLPATES (Wodehouse) Iversen and Troels-Smith, 1953

Genus CYCADOPITES Wodehouse *ex* Wilson and Webster, 1946

*Type species:* *Cycadopites follicularis* Wilson and Webster, 1946.

*Cycadopites nitidus* (Balme) de Jersey, 1964

Plate 9, Figure 8

*Figured specimen:* Slide S1545, stage co-ordinates 24.2, 102.2; dimensions  $43 \times 21$  microns. Co-ordinates of lower right hand corner of cover glass 26.9, 83.0.

*Locality:* D.R.D.3, 113 feet, 5 inches.

*Distribution:* Upper Jurassic and Lower Cretaceous of Western Australia (Balme, 1957); Cretaceous of south-eastern Australia (Dettmann, 1963); Jurassic of Walloon Coal Measures, Marburg Sandstone (de Jersey, 1959, 1963); Rhaetic of Hundary (Venkatachala and Goczan, 1964); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Upper Triassic of Tasmania (Playford, 1965); Upper Triassic of Bundamba Group (de Jersey, 1964); Triassic of Ipswich Coal Measures (de Jersey, 1962); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (this paper).

## RECYCLING OF PERMIAN MIOSPORES

In many areas sediments of the Rewan Formation overlie coal measures of Permian age. These Permian sediments are, in general, rich in miospores; hence some recycling of Permian species may be anticipated. The extent of such recycling is however difficult to determine, particularly in the basal portion of the Formation. This is because the presence of Permian species in basal Rewan assemblages could be explained equally well by upward extension of their ranges, as by recycling from underlying strata. However, there is more convincing evidence for recycling in the upper part of the sequence, particularly in the case of one sample (D.R.D.13, 276 feet, 7 inches). Characteristic Permian species present in this assemblage include *Acanthotriletes tereteangulatus*, *Dulhuntyispora parvithola*, *Granulatisporites micronodosus*, *Protohaploxypinus limpidus*, and *Striatoabietites multistriatus*. These species are regular and persistent components of assemblages from the uppermost Baralaba Coal Measures and basal Rewan Formation, but are absent or extremely rare in the intervening (middle Rewan) section. Consequently their association in an assemblage from a level thousands of feet higher in the sequence strongly favours localized reworking of Permian miospores at this level.

Apart from this example, there appear to be relatively few other cases where significant reworking of Permian species has occurred. As indicated above, Permian species present in basal Rewan assemblages may be indigenous, rather than recycled components of the Rewan microflora. Some evidence in favour of this view is provided by the preservation of such species, e.g. *Protohaploxypinus limpidus*. Specimens of this species, in basal Rewan assemblages, exhibit the fair to poor type of preservation typical of other components of the assemblages; better preservation, typical of assemblages from the underlying Permian coal measures, would be expected if they had been recycled.

The conclusion is evident, that recycling of Permian species has not been of marked importance in the assemblages studied. It seems probable that this is because there was relatively continuous deposition of the sediments in the section studied, without major time breaks in the sequence. On the western side of the basin, on the other hand, there is a disconformity between the Rewan Formation and the underlying coal measures. With an appreciable time break during which the Permian sediments were exposed to erosion there would thus be more likelihood of reworking of Permian species. Selection of a section for study, on the eastern side of the basin, has consequently not only provided assemblages from a thick stratigraphic sequence, but has also reduced opportunities for recycling of Permian species, and so minimised difficulties in interpreting biostratigraphic data.

## EFFECT OF FACIES ON MICROFLORAL ASSEMBLAGES

A striking feature of the Rewan Formation is the presence of "red-beds", consisting dominantly of chocolate mudstone; this distinctive lithology assists in distinguishing the Formation from other stratigraphic units in the succession. As this red-bed lithology indicates a specialized environment of deposition, one of the principal objectives of the present investigation has been to ascertain the effect of this specialized environment on the microfloral assemblages.

In the section studied, shown diagrammatically in Figure 2, red-beds are confined to the middle and lower portions of the formation; the finer sediments in the uppermost 2000 feet of the sequence consist of grey and greenish-grey shale and mudstone. Chocolate mudstone forms a prominent part of the section penetrated in D.R.D.15, D.R.D.17, D.R.D.18 and D.R.D.28; it is of minor significance in D.R.D.19, near the base of the sequence, where only one thin (2 inch) band was recorded.

Processing of samples of the chocolate mudstone showed that the yield of carbonaceous material, including plant microfossils, was relatively low in all cases. In each case the small amount of maceration residue obtained consisted very largely of opaque carbonaceous matter; the yields of miospores were so low, in comparison with those from the associated grey shales, that the investigation was concentrated on the latter. Consequently no detailed comparison of assemblages from the chocolate mudstone with those of the associated sediments has been attempted. However the assemblage from one sample of chocolate mudstone has been recorded; this is the



sample from D.R.D.15, 331 feet, 9 inches. This gave a very low yield of miospores, about 20 specimens being observed in a study of the whole of the maceration residue, spread on four microslides. The following species were recorded:

*Alisporites* sp.  
*Biretisporites* sp.  
*Densoisporites playfordi*  
*Granulatisporites* sp.  
 cf. *Guttatisporites* sp.  
*Inaperturopollenites* sp.

All these species are present in the associated grey mudstones and shales in this part of the sequence. As indicated above, detailed comparisons of assemblages from the grey mudstones with those from the chocolate mudstones have not been attempted because of the low yields from the latter. One feature of interest is the presence of *Densoisporites playfordi*, which indicates that the plant from which these spores were derived was able to adapt to the specialized environment in which the chocolate mudstone was deposited.

Although direct detailed comparison of assemblages from grey and chocolate mudstones has not been attempted, interesting results have emerged from comparison of assemblages from grey mudstones, interbedded with the chocolate mudstones in D.R.D.15, with those from the higher section in D.R.D.14, which contains no red-beds. This comparison reveals changes in the assemblages, which can be summarized as follows:

- (1) *Alisporites* spp. Species of this genus, which form 1.5 to 5 per cent of the assemblages from D.R.D.15, increase in abundance in the section in D.R.D.14, where they comprise from 9.5 to 48 per cent of the assemblages.
- (2) *Aratrisporites* spp. The combined proportions of *Aratrisporites rugulatus* and *A. wollariensis* are 0.5 per cent or less in the assemblages from the red-bed facies of D.R.D. 15, but are much greater (up to 84.5 per cent) in some of the assemblages from D.R.D.14.
- (3) *Densoisporites playfordi*. This species was present in all except one of the samples from D.R.D.15, its proportions ranging up to 3 per cent of the total. On the other hand, it was recorded, as a rare component, in only one assemblage from D.R.D.14.
- (4) *Discisporites psilatus*. The proportions of this species range from 2 to 9 per cent in the assemblages from D.R.D.15; it is absent from all assemblages recorded from D.R.D.14.
- (5) *Marsupipollenites klausii*. This species, present in assemblages from D.R.D.15, is absent from those of D.R.D.14.
- (6) *Protohaploxylinus samoilovichii*. In contrast to its regular and persistent occurrence, forming from 5.5 to 17.5 per cent of the assemblages from D.R.D.15, *P. samoilovichii* has not been recorded from the section in D.R.D.14.
- (7) *Striatissaccus novimundi*. Like the preceding species, *S. novimundi* is generally more abundant in the section containing the red-bed facies. Its proportions in samples from D.R.D.15 range up to 7.5 per cent, while it is rare or absent in assemblages from D.R.D.14.

(8) *Total of Striatites*. Striate pollens are common in assemblages from D.R.D.15, in which their proportions range from 14 to 43.5 per cent. They are relatively rare (1 per cent or less of the total) in assemblages from D.R.D.15.

These comparisons indicate that assemblages from the grey mudstones are markedly affected by the presence, or absence of red-beds interbedded in the sequence. Briefly stated, the principal changes which take place in passing upwards from the section in D.R.D.15 to that in D.R.D.14 are (a) marked reduction in the proportion of striate bisaccate pollens, (b) increase in the total percentage of *Alisporites*, and (c) increase in the proportion of *Aratrisporites* (comprising the two species, *A. rugulatus* and *A. wollariensis*).

Although there is thus a close relationship between facies and composition of the microfloras, the reasons for this relationship are more speculative. This is because the mechanism of formation of the red-beds is not entirely clear; furthermore little is known of the geology of the environments which favoured various components of the vegetation, represented by miospore species. Concerning the former, Loughnan, Ko Ko, and Bayliss (1964. pp. 74-76) have discussed the origin of similar red-beds in the Narrabeen Group of New South Wales. Although several mechanisms of formation are considered, that which is most favoured implies that the red material resulted from a process of lateritisation. If this mechanism also applies to the red-beds of the Rewan Formation, then the parent plants of the striate bisaccate pollens were presumably adapted to a climate with an alternation of wet and dry seasons, such as characterizes the formation of laterites. Extending this hypothesis further, the disappearance of the red-bed facies (in the section of D.R.D.14) may have been related to a change in the climate to one with rainfall more uniformly distributed throughout the year. Such a climate would have favoured moisture-loving plants, such as Lycopods, from which species of *Aratrisporites*, e.g. *A. wollariensis*, are probably derived. Consequently a climatic change of this nature may explain both the disappearance of red-beds from the sedimentary section and the marked increase in the proportions of *Aratrisporites* in the assemblages.

A study has also been made of changes in composition of the assemblages, related to the development of a red-bed facies in the basal part of the Formation. Here, however, the change in lithology is a more gradual one, in contrast to the abrupt change from the section in D.R.D.15 to that of D.R.D.14, where there is a complete disappearance of the red-bed facies. Thus, in following the lithological sequence downwards from D.R.D.28, in the section of which chocolate mudstone is a prominent component, there appears to be a gradual change, rather than an abrupt disappearance of the red-beds. Even in D.R.D.19, near the base of the Rewan sequence, there was still recorded one thin (2 inch) band of chocolate mudstone. The principal differences between the assemblages from D.R.D.19 and those from D.R.D.28 can be summarized as follows:

- (1) *Discisporites psilatus*. This species is relatively rare (less than 0.5 per cent) in an assemblage from D.R.D.19,



but much more common (2 to 10 per cent) in assemblages from D.R.D.28.

(2) *Densoisporites playfordi*. Assemblages from D.R.D.28 provide the first record of *D. playfordi* in the Rewan sequence; it is completely absent from the assemblages of D.R.D.19 and N.S.150.

(3) *Striatissaccus novimundi*. This species constitutes 2 per cent of the total, in the single assemblage recorded from D.R.D. 19; its proportion tends to be higher (up to 7.5 per cent) in those from D.R.D. 28.

(4) *Total of Striatites*. Striate bisaccate pollens comprise 7 percent of the microflora in the assemblage from D.R.D. 19; they are somewhat more abundant (up to 15.5 per cent) in some of the assemblages from D.R.D. 28.

The conclusion is thus evident that, while there are some changes in composition of the assemblages, associated with the development of a red-bed facies in the basal part of the sequence, these are of relatively minor significance. They are much less marked than the profound changes in the microfloras from D.R.D.15 to D.R.D.14, discussed above. In general terms, it seems likely that the gradual development of the red-bed facies in the basal Rewan Formation is accompanied by a gradual change in the microflora, while, at a higher level, the abrupt elimination of the red-bed facies is accompanied by an abrupt change in the miospore assemblages.

Finally, consideration must be given to the facies change which takes place at the base of the sequence, where the coal-bearing sediments of the Baralaba Coal Measures are overlain by Rewan sediments, which lack any significant coal seams. This facies change is accompanied by marked changes in the assemblages, including: (1) the decline in abundance and eventual disappearance of striate species, such as *Protohaploxylinus limpidus*, *Striatoabietites multistriatus*, and *Striatopodocarpites fusus*, (2) the disappearance of the distinctive species, *Dulhuntyispora parvithola*, and (3) the appearance of *Striatissaccus novimundi*, *Discisporites psilatus*, *Dictyophyllidites mortoni*, and *Cyathidites breviradiatus*. However, in this case it is not clear whether facies change is the only, or the major factor responsible for these changes in the assemblages. The possible occurrence of a time break between the Baralaba Coal Measures and Rewan Formation in this area cannot be entirely excluded; a hiatus at this level could explain the changes in microfloral composition equally as well as facies change. The problem cannot be resolved from present data, but it seems likely that further evidence could be obtained by study of the microfloral succession in the transition from the coal measures to the Rewan Formation in other parts of the Bowen Basin.

#### MICROFLORAL SEQUENCE IN THE REWAN FORMATION

In the stratigraphic diagram of the section studied (Figure 2), the vertical stratigraphic relationships of the various borehole sections are indicated. The percentage distribution of species and genera in this composite section of the Formation has been charted in Figure 3, to illustrate their vertical stratigraphic sequence. In order

to provide more space for recording the microfloral sequence, sampling gaps evident in Figure 2 are not shown to scale in Figure 3. However the stratigraphic positions of assemblages recorded in the latter are indicated in relation to each other and to the base and top of the Formation. From Figure 3 it is evident that there are progressive changes in composition of the microfloras, in this relatively thick sequence. The more significant of these, from the stratigraphic aspect, can be summarized as follows:

(1) The appearance of *Striatissaccus novimundi*, *Discisporites psilatus*, *Dictyophyllidites mortoni* and *Cyathidites breviradiatus*. These species appear at, or near, the base of the Rewan Formation. Apart from a doubtful specimen of *S. novimundi* from a slightly lower horizon, the first three of these have been recorded in an assemblage from N.S.150, 420 feet, 2 inches, less than 10 feet above the base of the Formation. The earliest record of *Cyathidites breviradiatus* is from the assemblage of D.R.D.19, about 400 feet above the base of the Rewan sequence.

(2) *Densoisporites playfordi*, *Kraeuselisporites saeptatus*, and *Rewanispora foveolata* are first recorded in assemblages from D.R.D.28. Their stratigraphic ranges can be charted only approximately, because of the gap in sampling below this level.

(3) Species, which make their first appearance in the section in D.R.D.18, are *Aratrisporites wollariensis*, *Guthoerlisporites concellosus*, *Kraeuselisporites cuspidus*, and *Lundbladispore willmotti*. Here again the ranges of these species are not precisely determined, because of the gap in sampling between D.R.D.18 and D.R.D.28.

(4) *Aratrisporites rugulatus* and *Voltziaceasporites heteromorpha* are first recorded in assemblages from D.R.D.17. The base of the range in each case is assumed to be between the levels of D.R.D.17 and D.R.D.18.

(5) The next major change in the microfloral assemblages is between the sections in D.R.D.15 and D.R.D.14. There is a marked decline in the proportion of striate bisaccate pollens, accompanied by increases in the percentages of *Alisporites* and *Aratrisporites*. As discussed in the preceding section, these and other changes in the microfloras can be related to lithology, i.e. the presence or absence of the red-bed facies. In view of this relationship to facies, it seems likely that stratigraphic correlation, based on such changes in the assemblages will be only of local application, within a restricted area.

(6) Species which first appear in assemblages from D.R.D.13 are *Aratrisporites tenuispinosus* and *Triadispora crassa*. The former becomes abundant in some assemblages from D.R.D.3, D.R.D.4 and D.R.D.16, then disappears in the basal part of the succeeding Clematis Sandstone.

The above discussion indicates that, on the basis of the successive appearance of selected species, biostratigraphic subdivision of this thick section of the Rewan Formation is possible. However, it will be necessary to study the lateral persistence of this distribution pattern, in other sections of the Formation, before attempting formal definition of biostratigraphic units.



Some evidence on the lateral persistence of certain elements of the microflora is provided by the biostratigraphic studies of Evans (1966). Four "palynological units", recorded successively as Tr1a, Tr1b, Tr2a and Tr2b, were recognized in the Rewan Formation. The evidence for recognition of these units, in relation to the microfloral sequence reported here, can be summarized as follows:

(1) *Unit Tr1a*. Evans states (1966, p. 59): "Unit P4 is rapidly replaced by a very different assemblage, unit Tr1a, in which *Quadriforites horridus* is present in abundance, *D. parvithola*, *M. triradiatus*, *Parasaccites* spp. are present in minor proportions, and in which new forms of monosaccate pollens ("*Nuskoisporites*" *radiatus* aff. *Trizonaesporites*), and striate saccate pollens (*Striatites*, aff. *Crustaesporites*), make their first appearance."

Assemblages similar to those of this unit have not been observed in the present study. The microfloras recorded here lack any definite specimens of *Quadriforites horridus*; furthermore the characteristic association of species reported has not been observed. From the data available, it is suggested that Unit Tr1a is missing from the sequence in this area on the eastern side of the basin. In terms of Evans's terminology, Unit P4 is here directly succeeded by Unit Tr1b. It seems likely that these differences are related to differences in the stratigraphic sequences between the eastern side of the basin and the western side, where Evans's palynological units were apparently established. If so, sediments containing the Tr1a assemblage may have been removed by erosion soon after deposition. An alternative explanation is that the Tr1a assemblage is a reflection of a specialized facies, and that sediments of similar age, but different lithology in other areas, may contain assemblages like those of the Upper Permian Unit P4.

(2) *Unit Tr1b*. Evans states (1966, p. 59). "The succeeding unit Tr1b contains no vestiges of the older, Permian, microflora, but includes the first appearance of *Taeniaesporites* spp., a fairly abundant content of *Alisporites* (*Pteruchus* types), a continuance of the large monosaccate and striate pollens introduced in unit Tr1a, a relatively rare occurrence of *Q. horridus*, and the introduction of a number of undescribed pteridophytic spores."

The base of this unit is marked by the first appearance of "*Taeniaesporites*" (= *Striatissaccus*). This corresponds to the base of Rewan Formation, in this section on the eastern side of the basin. It thus seems likely that the first appearance of this species may provide a useful marker over a large part of the Bowen Basin.

(3) *Unit Tr2a*. Evans states (1966, p. 59): "A change in the gymnospermous pollen content of the microfloras occurred at the beginning of unit Tr2a, where the large monosaccate and striate forms almost disappear, and where *Taeniaesporites* types become prominent for the first time, associated with the appearance of *Lundbladispore*."

Some difficulty is experienced in recognizing this unit, in the sequence currently recorded. This is because rare specimens of *Lundbladispore* sp. are known from the sample from N.S.150, 420 feet 2 inches. This is the same assemblage in which *Striatissaccus* (= *Taeniaesporites*),

marking the base of unit Tr1b, first appears. The first appearance of the species *Densoisporites playfordi* (= *Lundbladispore playfordi*) seems likely to provide a more reliable marker than the introduction of the genus, on the eastern side of the basin. It also appears to correspond more closely, in stratigraphic level, to the base of Unit Tr2a, in Evans's sequence.

(4) *Unit Tr2b*. Evans states (1966, pp. 59, 60): "*Lundbladispore* spp. make their last appearance in Tr2b in association with the first appearance of *Aratrisporites* spp. *Taeniaesporites* spp. are a small component of the gymnospermous pollen content, but *Alisporites* spp. begin to be prominent at this level before they become the dominant constituent of the remaining Triassic (unit Tr3)."

Use of the first appearance of *Aratrisporites* spp., to mark the base of this unit, would correspond to the first appearance of *A. wollariensis*, in the sequence recorded in this paper. However, this species is so rare in the assemblages where it is first recorded, that its first appearance seems difficult to determine precisely. In the section recorded here, *Kraeuselisporites cuspidus* and *Lundbladispore willmotti* appear at about the same stratigraphic level; being larger, more distinctive species their initial appearances may be more useful than that of *A. wollariensis*, in future correlation studies.

From the above discussion, it is evident that some modification of Evans's system of palynological units may be necessary to enable effective microfloral zonation to be achieved, throughout the Bowen Basin. In view of the relative thickness of the section on which the current study has been based, it is suggested that it represents an expanded version of the sequence studied by Evans or, more probably, that the upper part of the section recorded here is not represented at all on the western side of the Basin. The present study, by recording the microfloral sequence through this thick section, will provide a reference section, for correlation studies in other developments of the Rewan Formation. Although sufficient evidence is not yet available, it seems likely that with further study formal recognition of biostratigraphic units in the Rewan Formation will eventually be possible, on the basis of miospore distribution.

## COMPARISON WITH OTHER AUSTRALIAN TRIASSIC MICROFLORAS

An interesting feature of the Rewan assemblages is the presence of distinctive elements of the Kockatea Shale microflora of Western Australia, described by Balme (1963). This was pointed out by Evans (1966, p. 59), who assigned the relevant part of the Rewan sequence to his palynological unit Tr2a. Species which are common to both Rewan and Western Australian assemblages include *Densoisporites playfordi*, *Kraeuselisporites cuspidus*, *K. saeptatus*, *Lundbladispore brevicula*, *L. willmotti*, *Osmundacidites senectus*, *Vitreisporites pallidus*, *Striatissaccus novimundi* and *S. obex*.

Study of Figure 3 indicates that these species have varying ranges within the Rewan sequence. *Striatissaccus novimundi* and *Vitreisporites pallidus*, for example, extend throughout the section recorded here, while other species,



notably those of *Kraeuselisporites* and *Lundbladispota*, have more restricted ranges. In the section studied, the assemblages which have most in common with the microflora of the Kockatea Shale are those from D.R.D.15, D.R.D.17 and D.R.D.18. On the basis of this close similarity, this middle part of the Rewan sequence is regarded as approximately coeval with the Kockatea Shale. As the latter is precisely dated by marine faunas (Dickins and McTavish, 1963) as early Scythian, a similar age is thus indicated for this portion of the Rewan sequence.

Differences which are evident between the Rewan and Kockatea microfloras, such as the absence of *Protohaploxylinus samoilovichii* from the latter, may be related to differences in local environments of deposition. While the Kockatea Shale was laid down in a marine environment, that of the Rewan Formation was non-marine or largely non-marine. Differences, both qualitative and quantitative, in the microfloras can be expected, as a reflection of these differing modes of origin of the sediments.

Elements of the Kockatea microflora have also been reported from the Ross Formation of Tasmania (Playford, 1965). These include *Lundbladispota brevicula*, *L. willmotti*, *Kraeuselisporites cuspidus* and *Densosporites playfordi*; as stated by Playford (1965, p. 201) their presence favours a Scythian (Lower Triassic) age for this Tasmanian assemblage. All the species of the latter have been recorded in the Rewan microflora, the similarity being strengthened by the presence of *Protohaploxylinus samoilovichii* in some abundance in both Tasmanian and Queensland assemblages. Accordingly, like the Kockatea Shale, the Ross Formation is correlated with some part of this thick Rewan section, the comparison being closest with assemblages from the middle portion of the sequence. There are differences between the Queensland and Tasmanian assemblages, notably the absence of *Striatissaccus novimundi* from the latter. However these differences could well be related to the "reconnaissance" nature of Playford's investigation (Playford, 1965, p. 275); more detailed studies of the Tasmanian material could lead to the discovery of additional species, present in the Rewan assemblages.

Other Tasmanian assemblages which may have equivalents in the Rewan microfloras are those of the Tiers Formation, recorded by Playford (1963). Distinctive species present in assemblages from the Tiers Formation include *Aratrisporites strigosus*, *A. tenuispinosus*, and *Tigrisporites playfordi*. Their presence favours correlation with a section which comprises the uppermost 1000 feet of the Rewan Formation and the basal 100 feet of the overlying Clematis Sandstone (de Jersey, 1968, pp. 22, 23).

From New South Wales Helby (1967) has recorded an assemblage of fifteen species from the Wollar Sandstone. This assemblage contains *Aratrisporites tenuispinosus* and *A. wollariensis*, the latter in considerable abundance. The presence of these species is suggestive of correlation with the uppermost Rewan Formation or basal Clematis Sandstone.

Appreciable differences in age and microfloral composition are evident between the Rewan assemblages,

recorded here, and other Triassic microfloras, described from Australia. As discussed previously (de Jersey and Hamilton, 1967, p. 23) Triassic microfloras from the Ipswich Coal Measures and Bundamba Group, in south-eastern Queensland, are of significantly younger aspect than those of the Moolayember Formation. Hence there are even greater differences in age and species content, between the Rewan assemblages and these younger microfloras. Similar considerations apply in relation to microfloras of Upper Triassic aspect described from Leigh Creek, South Australia by Playford and Dettmann (1965) and from the Brady Formation of Tasmania by Playford (1965). Finally, an assemblage from Permo-Triassic transition beds in the Sydney Basin, described by Hennelly (1958), is similar to that of palynological unit Tr1a of Evans (1966, p. 59). As discussed in the preceding section of this paper, this unit, although recorded by Evans from another part of the Bowen Basin, is not represented in the section studied, on the eastern side of the Mimosa Syncline. Its absence may be due to erosion or non-deposition of the relevant section of sediments, or to its being a facies variant of the P4 assemblage of the Upper Permian.

#### AGE OF THE REWAN FORMATION

The present study has indicated two sources of palynological evidence on the age of the Rewan Formation. These are (1) direct comparison of the microfloral sequence with that of the standard Triassic succession of Central Europe and (2) comparison of the microfloras with those of other formations, which are accurately dated by marine faunas.

From the former aspect, direct comparison of the Rewan and European sequences has resulted from the discovery of distinctive European species in the former, combined with evidence from recent papers on the ranges of these species in the Triassic of Europe. The three species concerned are (a) *Striatissaccus novimundi*, (b) *Voltziaceasporites heteromorpha*, and (c) *Triadispora crassa*. On the basis of recent publications (Klaus, 1965; Visscher, 1966; Schulz, 1966; Reinhardt and Schön, 1967) these appear respectively (a) close to the Permian-Triassic boundary, (b) in the middle Scythian (middle Bunter Sandstone), and (c) in the upper Scythian (Röt or upper Bunter Sandstone). These three species appear in the same order in the Rewan section recorded here. Thus *Striatissaccus novimundi* appears near the base of the Rewan Formation (in assemblages from D.R.D.19 and N.S.150), *Voltziaceasporites heteromorpha* near the middle of the Formation (in assemblages from D.R.D.17), and *Triadispora crassa* near the top of the Formation (in an assemblage from D.R.D.13). By equating these successive appearances the basal Rewan Formation (in this section) is placed as basal Scythian, the middle Rewan Formation as middle Scythian and the upper Rewan Formation (and possibly the basal Clematis Sandstone) as upper Scythian.

Consideration of this correlation, in the light of evidence from other microfloras, indicates that additional data are required to determine the age of the basal part of the Rewan sequence. This is because *Striatissaccus novimundi*, which in central Europe first appears persis-



tently at the base of the Triassic (Klaus, 1965, p. 291), has been recorded from the Upper Permian of England (Clarke, 1965b, p. 334). In the absence of evidence of diachronism of the strata concerned, the initial appearance of this species appears to be slightly affected by local environmental conditions. Accordingly, additional evidence on the age of the lower part of this Rewan Section has been examined, and may be summarized as follows:

As indicated in a preceding section, assemblages from D.R.D.18 include several distinctive species from the accurately dated Scythian microflora of Western Australia. These species comprise *Densosporites playfordi*, *Kraeuselisporites cuspidus*, *K. saeptatus*, *Lundbladispore willmotti*, *Striatissaccus novimundi* and *S. obex*. The presence of these distinctive forms provides strong evidence for correlation with this Scythian microflora; the upper 6000 feet of this Rewan section is thus assigned with confidence to the Triassic.

Below the level of D.R.D.18, six assemblages have been recorded from D.R.D.28, which cored a section about 1500 feet above the base of the Formation. Although these assemblages do not contain as many of the Scythian forms as those from D.R.D.18, they still include four species—*Densosporites playfordi*, *Grebespora concentrica*, *Kraeuselisporites saeptatus*, and *Striatissaccus obex*—which have been recorded from Scythian, but not from Permian assemblages. Consequently there is evidence for including the section down to the level of D.R.D.28 also in the Triassic.

Below this level, a record of microfloras from the basal 1500 feet of the Rewan sequence is provided by four assemblages from N.S.150 and one from D.R.D.19. These assemblages do not contain any distinctive species which are confined to precisely dated Scythian microfloras. However, the presence of three species—*Cyathidites breviradiatus*, *Dictyophyllidites mortoni*, and *Discisporites psilatus*—favours a Triassic age as while they are persistent components of the Rewan assemblages they have not been recorded from any Permian microfloras. Hence on this negative evidence this basal portion, about 1500 feet in thickness, of the Rewan sequence is tentatively regarded as Lower Triassic.

Knowledge of the microfloral sequence in this basal part of the Rewan succession is mainly based on assemblages from N.S.150, which was drilled through the basal part of the Rewan Formation into the underlying Baralaba Coal Measures. Of the eight assemblages studied, the lowest three came from the latter; they are of typical Upper Permian aspect, without any admixture of Triassic forms and could be assigned to palynological unit P4 of Evans (1966). Overlying the coal measures in this area (between the depths of about 460 feet and 540 feet in N.S.150) is a section which contains a large proportion of volcanic conglomerate. A thin coal band, from a depth of 523 feet 3 inches, yielded an assemblage which, apart from the presence of one doubtful specimen of *Striatissaccus novimundi*, was of similar Permian aspect to those of the Baralaba Coal Measures. Thus if this coal band is representative of this section this conglomeratic section should also be assigned to the Upper Permian. Overlying the latter section are sediments of

Rewan-type lithology. The assemblages from this upper section, including one from a depth of 420 feet 2 inches, near its base, contain *Dictyophyllidites mortoni* and *Discisporites psilatus* and, as indicated above, are provisionally assigned to the Lower Triassic.

This microfloral evidence on the ages of the assemblages is in conformity with lithological grouping of the sediments in this section. Miss H. Colton (pers. comm.) places the boundary between the Rewan Formation and Baralaba Coal Measures at a depth of 421 feet in N.S.150, thereby placing the conglomeratic section at the top of the latter unit. Below this boundary the assemblages are of Upper Permian aspect; above it they are provisionally regarded as Lower Triassic.

The above conclusions on the age of the Rewan Formation, and of the overlying Triassic units, are summarized in Table 1. It should be noted that this table is based on the succession in the Mimosa Syncline, where the formations attain their maximum development. In other parts of the Bowen Basin the formations are thinner and significant time breaks occur in the sequence. The broken line representing the boundary between the Baralaba Coal Measures and Rewan Formation, indicates that this boundary is located only approximately in relation to the Permian-Triassic boundary; as discussed above, the basal part of the Rewan Formation is tentatively assigned to the Lower Triassic.

TABLE 1. AGES OF TRIASSIC FORMATIONS, BOWEN BASIN

|                    |          |                              |
|--------------------|----------|------------------------------|
| UPPER<br>TRIASSIC  | RHAETIAN |                              |
|                    | NORIAN   |                              |
|                    | CARNIAN  |                              |
| MIDDLE<br>TRIASSIC | LADINIAN | MOOLAYEMBER<br>FORMATION     |
|                    | ANISIAN  | CLEMATIS SANDSTONE           |
| LOWER<br>TRIASSIC  | SCYTHIAN | REWAN<br>FORMATION           |
| UPPER<br>PERMIAN   |          | BARALABA<br>COAL<br>MEASURES |

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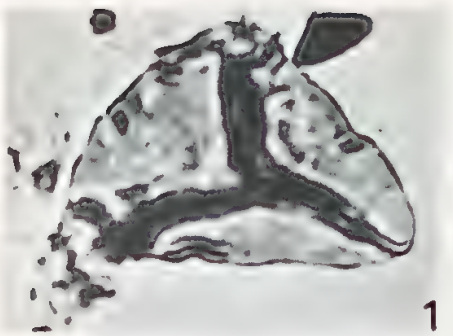


## PLATE 1

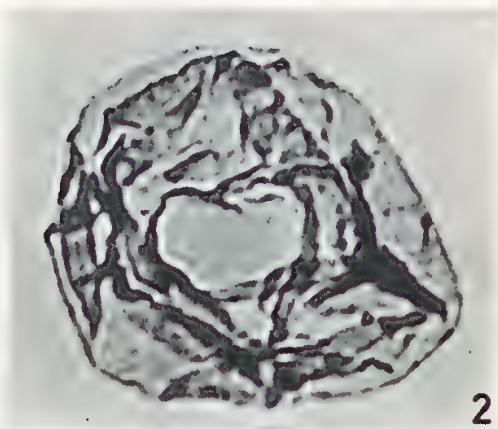
(All photographs approximately  $\times 1000$ )

- Figure 1 —*Biretisporites* sp. A (equatorial focus).  
Figure 2 —*Calamospora tener* (Leschik) de Jersey, 1962 (equatorial focus).  
Figure 3 —*Dictyophyllidites mortoni* (de Jersey) Playford and Dettmann, 1965 (equatorial focus).  
Figure 4 —*Converrucosisporites rewanensis* sp. nov. (specimen with relatively few verrucae; equatorial focus).  
Figure 5 —*Converrucosisporites rewanensis* sp. nov. (Holotype—specimen with verrucae fairly evenly distributed; equatorial focus).  
Figure 6 —*Acanthotriletes tereteangulatus* Balme and Hennelly, 1956 (median focus).  
Figure 7 —*Converrucosisporites cameroni* (de Jersey) Playford and Dettmann, 1965 (median focus).  
Figure 8 —*Cyathidites breviradiatus* Helby, 1967 (Proximal focus).  
Figure 9 —*Granulatisporites micronodosus* Balme and Hennelly, 1956 (median focus).  
Figure 10—*Osmundacidites fissus* (Leschik) Playford, 1965 (median focus).  
Figure 11—*Osmundacidites senectus* Balme, 1963 (proximal focus).

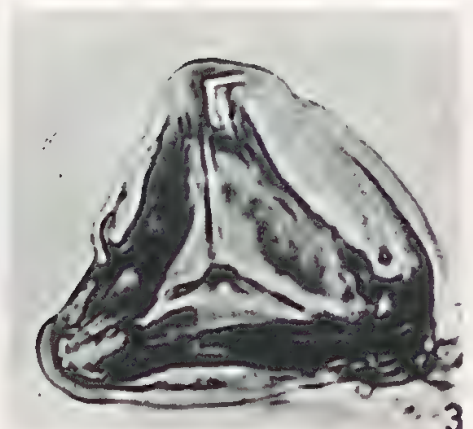




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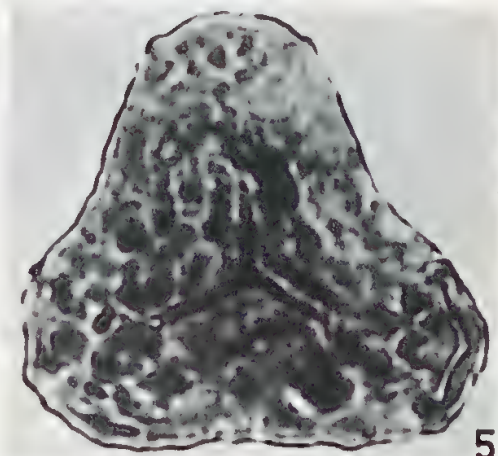
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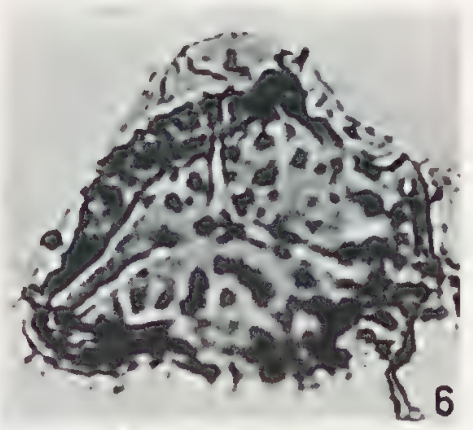
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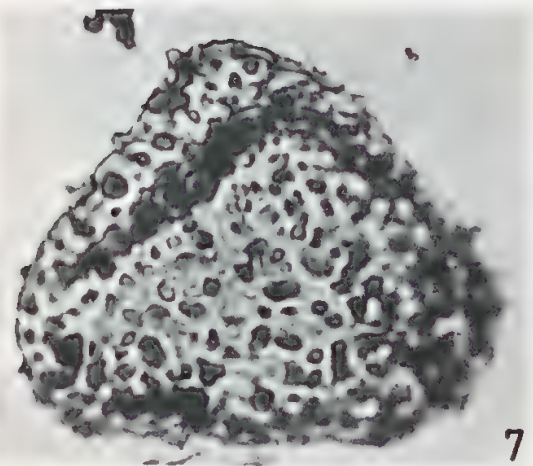
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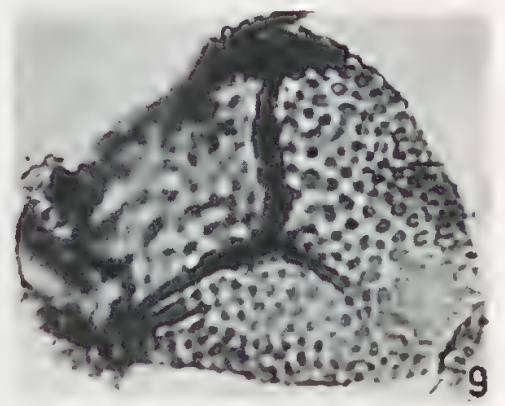
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## PLATE 2

(All photographs approximately  $\times 1000$ , unless otherwise stated)

Figure 1 —*Densoisporites playfordi* (Balme) Dettmann, 1963 (equatorial focus).

Figure 2 —*Nevesisporites limatulus* Playford, 1965 (proximal focus).

Figure 3 —*Lundbladispota* sp. (distal focus).

Figure 4 —*Lundbladispota brevicula* Balme, 1963 (equatorial focus).

Figure 5 —*Lundbladispota willmotti* Balme, 1963 (equatorial focus).

Figure 6 —cf. *Densoisporites* sp. (equatorial focus).

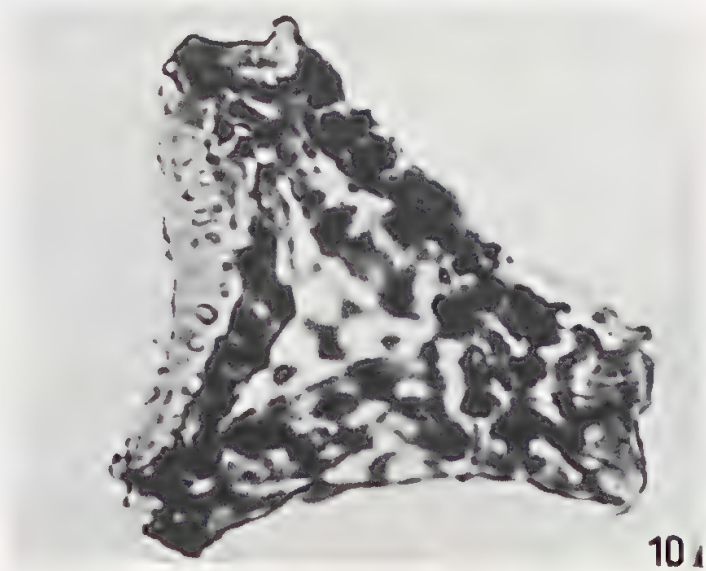
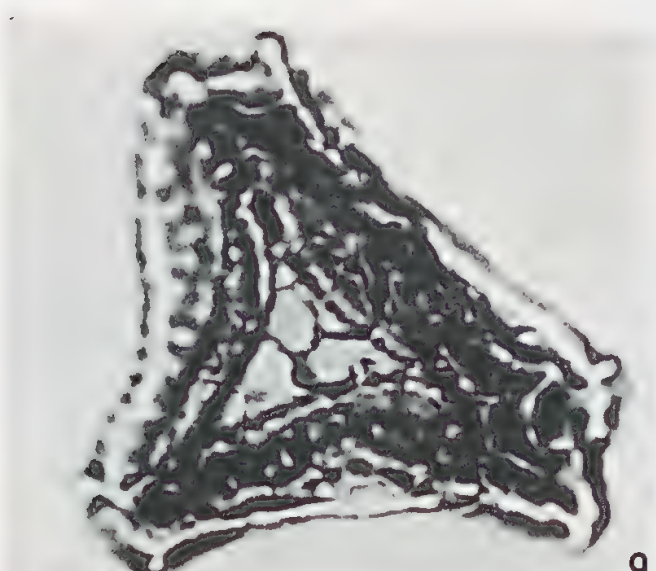
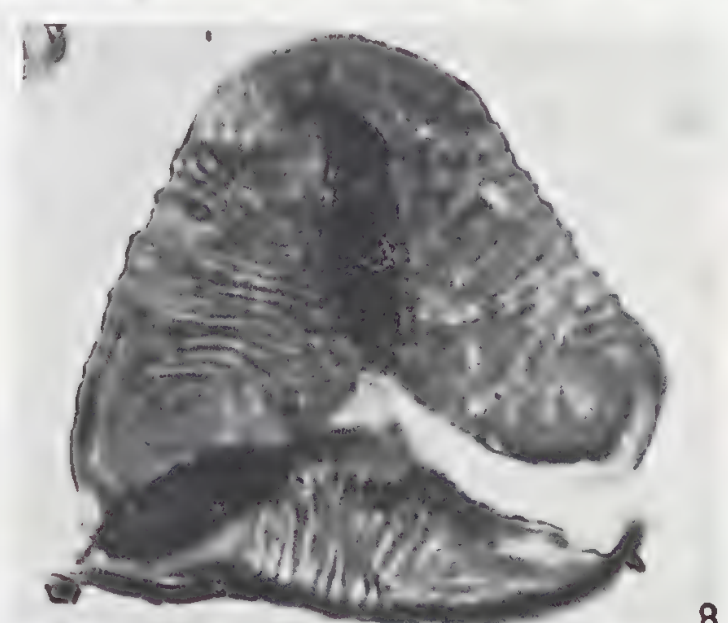
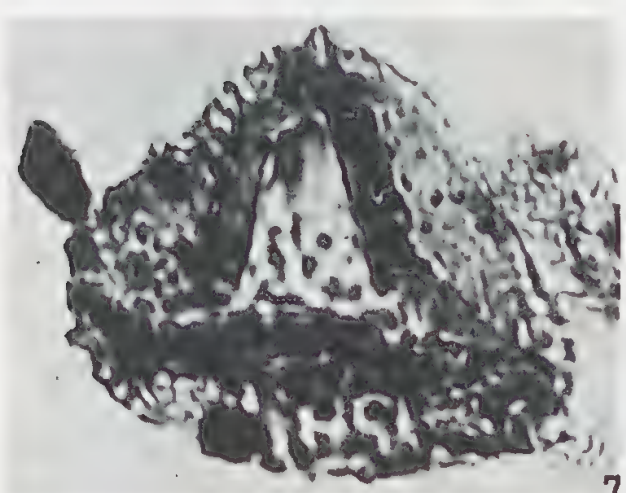
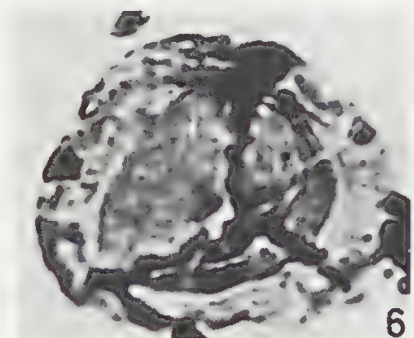
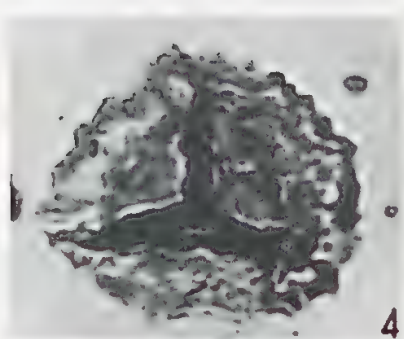
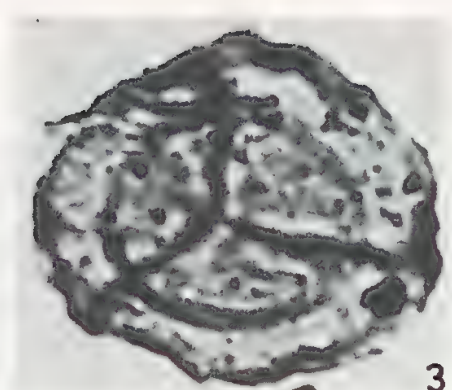
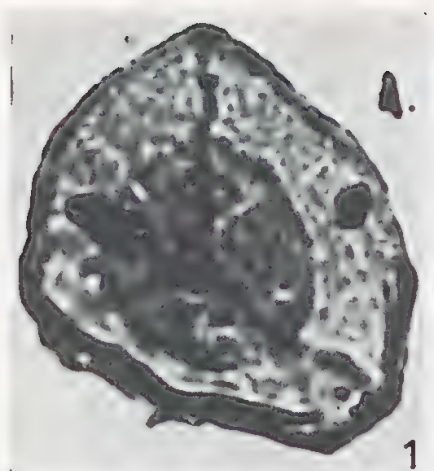
Figure 7 —*Indospora clara* Bharadwaj, 1962 (median focus).

Figure 8 —*Tigrisporites playfordi* de Jersey and Hamilton, 1967 (X1500 —median focus).

Figure 9 —*Indospora reticulata* de Jersey, 1968 (distal focus).

Figure 10 —*Indospora reticulata* de Jersey, 1968 (equatorial focus).







### PLATE 3

(All photographs approximately  $\times 1000$ )

- Figure 1 —*Kraeuselisporites saeptatus* Balme, 1963 (median focus).  
Figure 2 —*Kraeuselisporites cuspidus* Balme, 1963 (equatorial focus).  
Figure 3 —*Aratrisporites* sp. cf. *A. banksi* Playford, 1965 (distal-equatorial focus).  
Figure 4 —*Aratrisporites tenuispinosus* Playford, 1965 (equatorial focus).  
Figure 5 —*Aratrisporites strigosus* Playford, 1965 (equatorial focus).  
Figure 6 —*Rewanispora foveolata* sp. nov. (Holotype, proximal focus).  
Figure 7 —*Rewanispora foveolata* sp. nov. (Holotype, distal focus).  
Figure 8 —*Rewanispora foveolata* sp. nov. (distal focus, showing well preserved foveolae).  
Figure 9 —*Rewanispora foveolata* sp. nov. (oblique equatorial view).  
Figure 10 —*Rewanispora foveolata* sp. nov. (median focus, showing intexine).



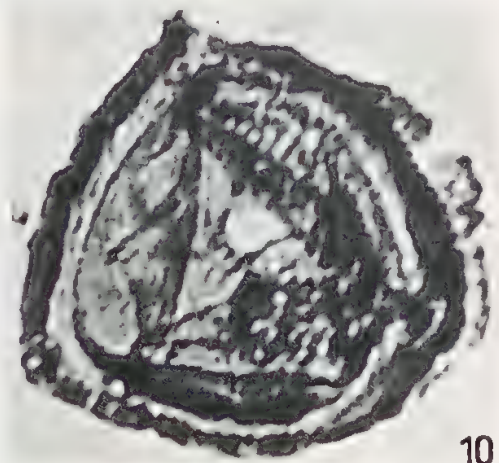
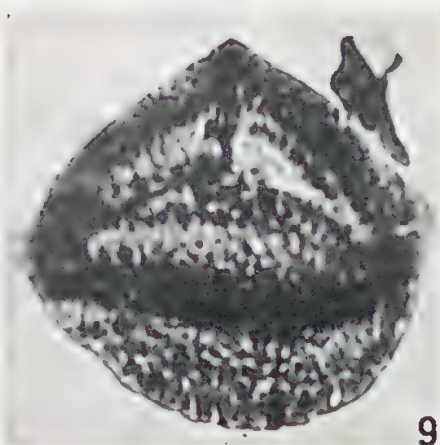
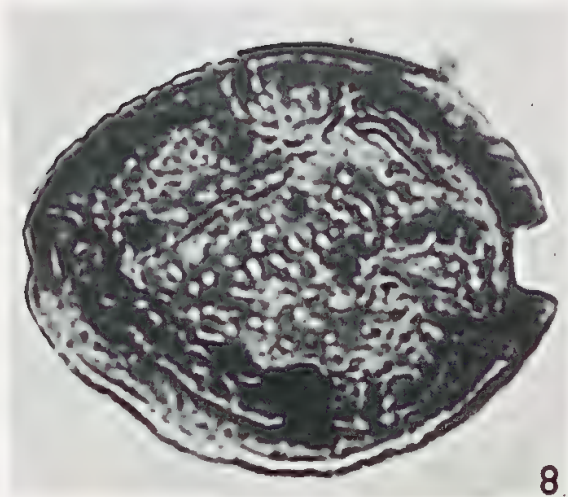
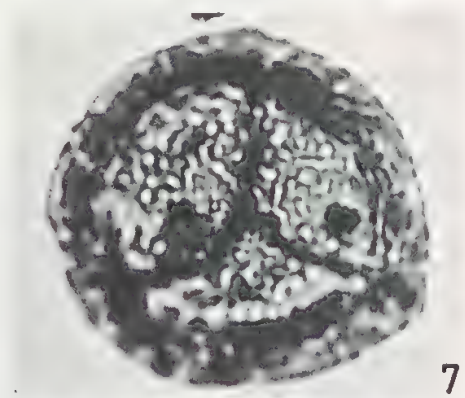
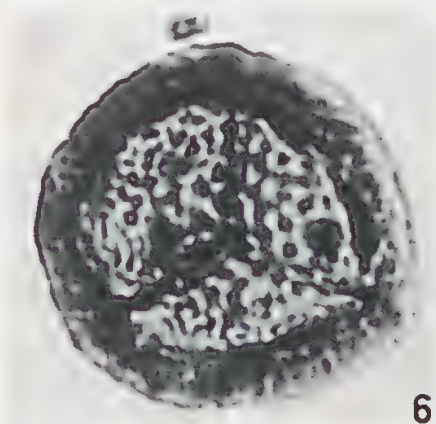
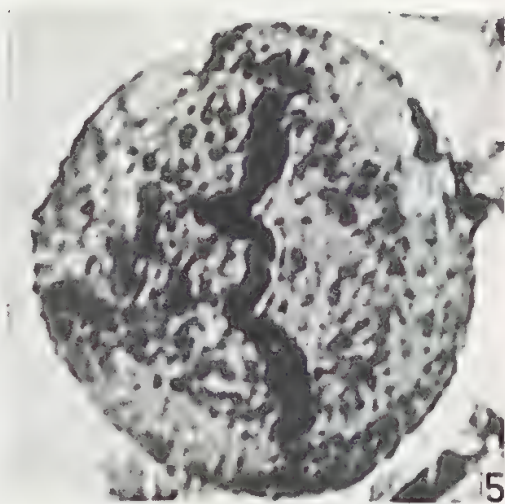
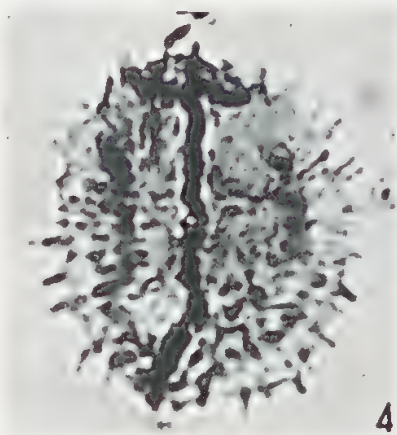
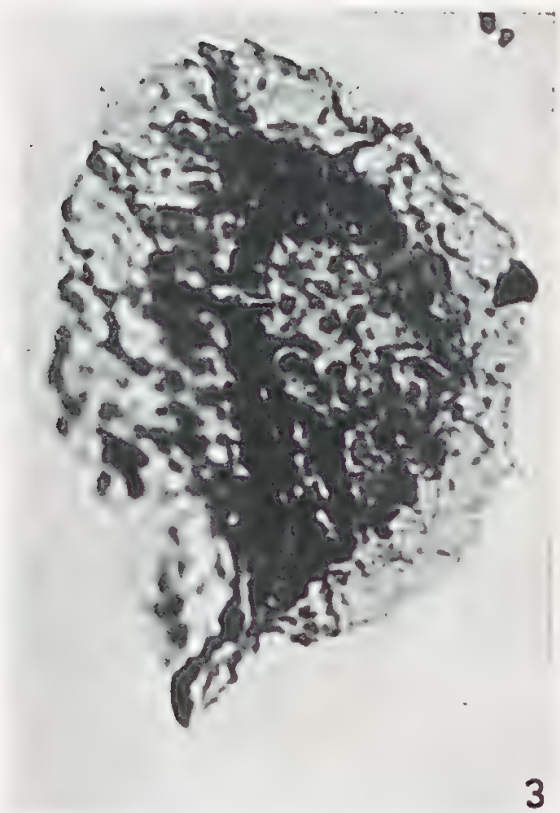
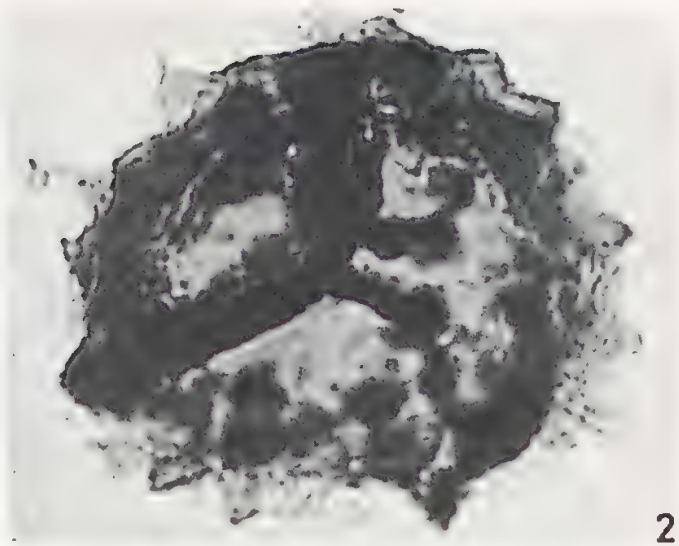
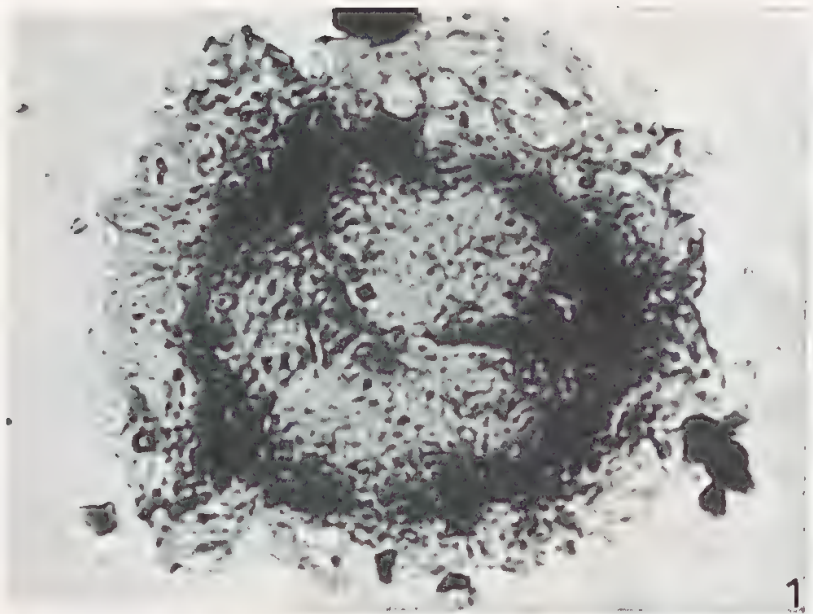


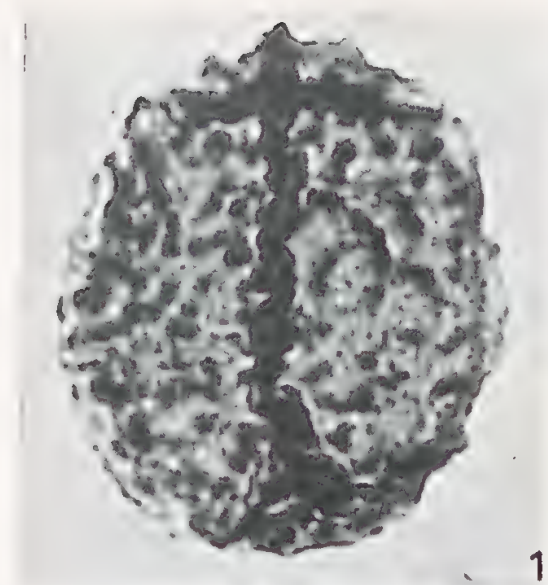
PLATE 3

#### PLATE 4

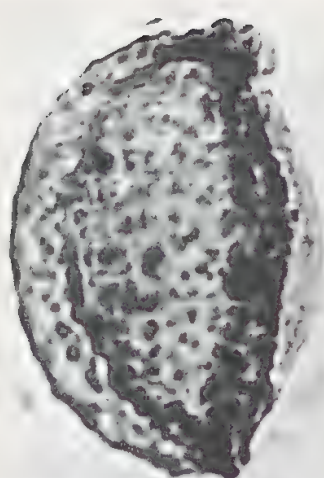
(All photographs approximately  $\times 1000$ , unless otherwise stated).

- Figure 1 —*Aratrisporites rugulatus* sp. nov. (Holotype, showing slight separation of layers at left hand side).
- Figure 2 —*Aratrisporites rugulatus* sp. nov. (lateral view).
- Figure 3 —*Aratrisporites rugulatus* sp. nov.
- Figure 4 —*Aratrisporites* sp. cf. *A. parvispinosus* Leschik *emend.* Playford, 1965 (median focus).
- Figure 5 —*Aratrisporites* sp. cf. *A. parvispinosus* Leschik *emend.* Playford, 1965 (median focus).
- Figure 6 —*Aratrisporites* sp. cf. *A. parvispinosus* Leschik *emend.* Playford, 1965 ( $\times 1500$ —spines on specimen in Plate 4, Figure 5).
- Figure 7 —*Aratrisporites* sp. cf. *A. parvispinosus* Leschik *emend.* Playford, 1965 ( $\times 1500$ —spines on specimen in Plate 4, Figure 4).
- Figure 8 —*Aratrisporites wollariensis* Helby, 1967 (median focus).
- Figure 9 —*Aratrisporites wollariensis* Helby, 1967 (median focus, showing folded inner layer).
- Figure 10—*Aratrisporites wollariensis* Helby, 1967 (median focus).
- Figure 11—*Aratrisporites plicatus* de Jersey and Hamilton, 1967 (median focus).
- Figure 12—*Aratrisporites wollariensis* Helby, 1967 (median focus, showing relatively large inner layer).
- Figure 13—*Aratrisporites wollariensis* Helby, 1967 (median focus).
- Figure 14—*Polypodiisporites ipsviciensis* (de Jersey) Playford and Dettmann, 1965 (median focus).

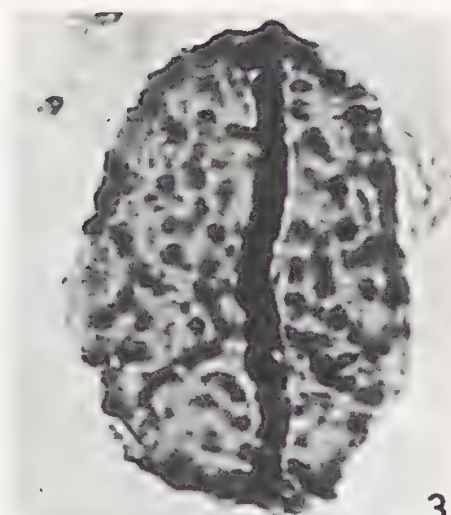




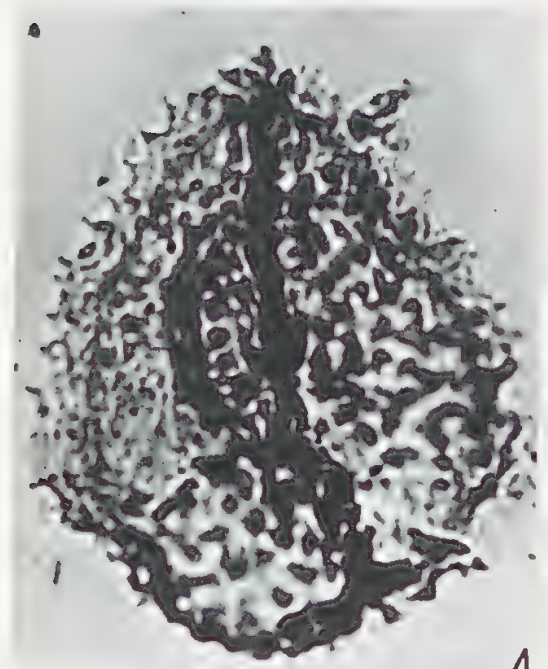
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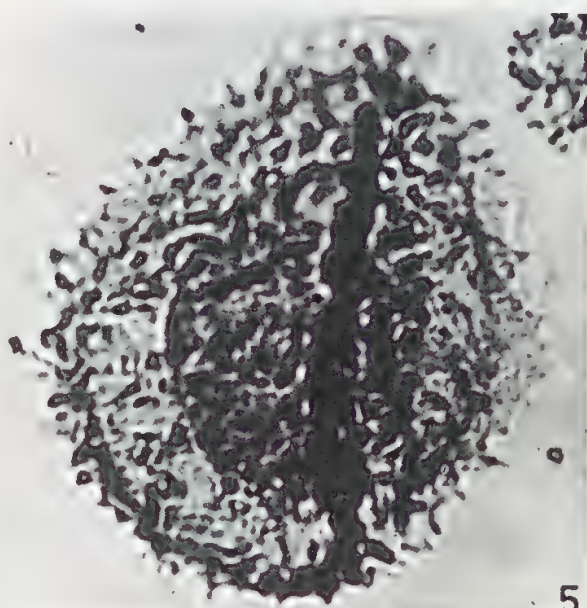
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3



4



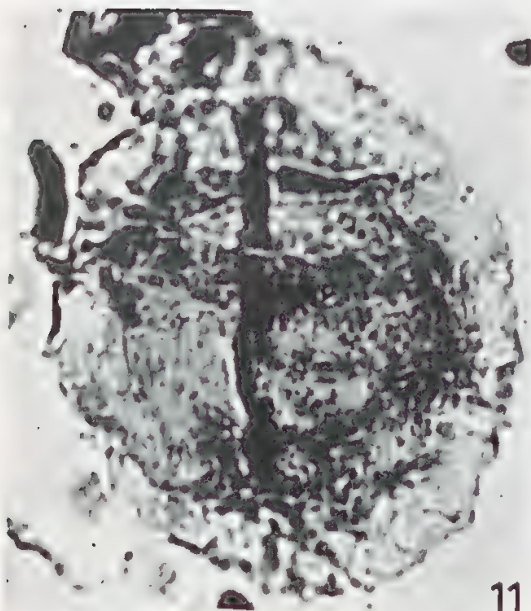
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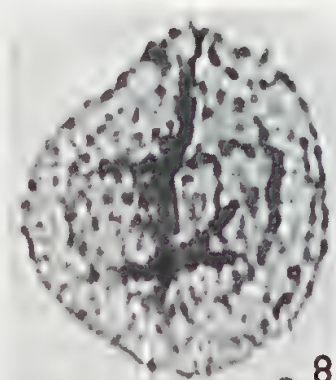
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7



11



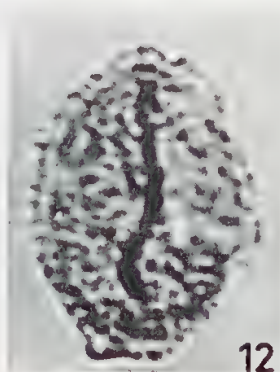
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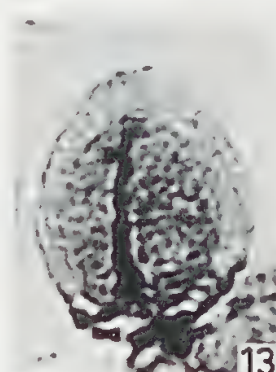
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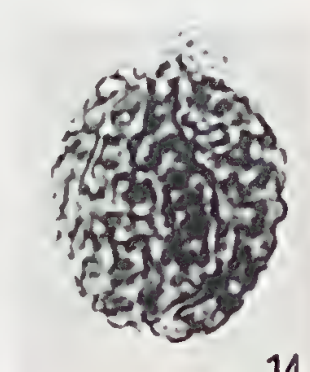
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12



13



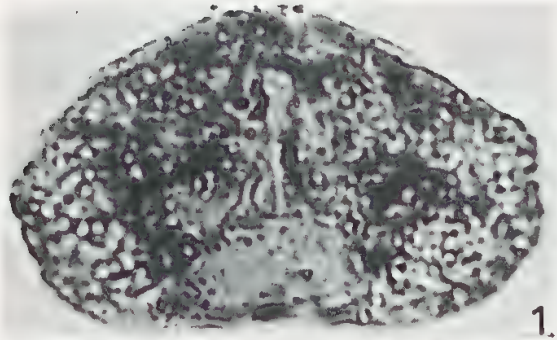
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## PLATE 5

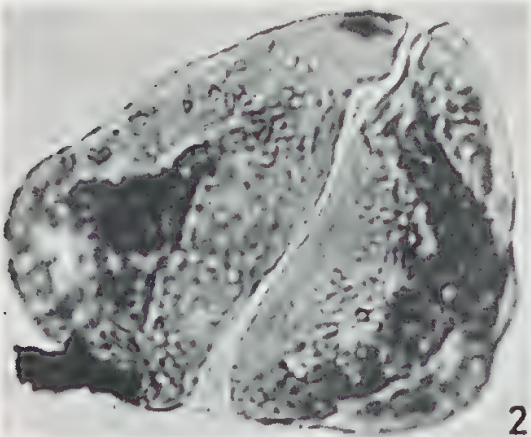
(All photographs approximately  $\times 1000$ )

- Figure 1 —*Sulcatisporites ovatus* (Balme and Hennelly) Bharadwaj, 1962 (distal focus).
- Figure 2 —*Sulcatisporites* sp. cf. *S. krauseli* Mädlar, 1964 (distal focus).
- Figure 3 —*Guthoerlisporites cancellosus* Playford and Dettmann, 1965 (median focus).
- Figure 4 —*Guthoerlisporites* sp. A (median focus).
- Figure 5 —*Klausipollenites staplinii* Jansonius, 1962 (median focus).
- Figure 6 —*Klausipollenites staplinii* Jansonius, 1962 (Specimen showing elongate corpus).
- Figure 7 —*Vitreisporites pallidus* (Reissinger) Nilsson, 1958 (median focus).
- Figure 8 —*Sulcosaccispora alaticonformis* (Malyavkina) de Jersey, 1968 (median focus).
- Figure 9 —*Alisporites australis* de Jersey, 1962 (distal focus).
- Figure 10—*Alisporites townrovi* Helby, 1967 (distal focus).





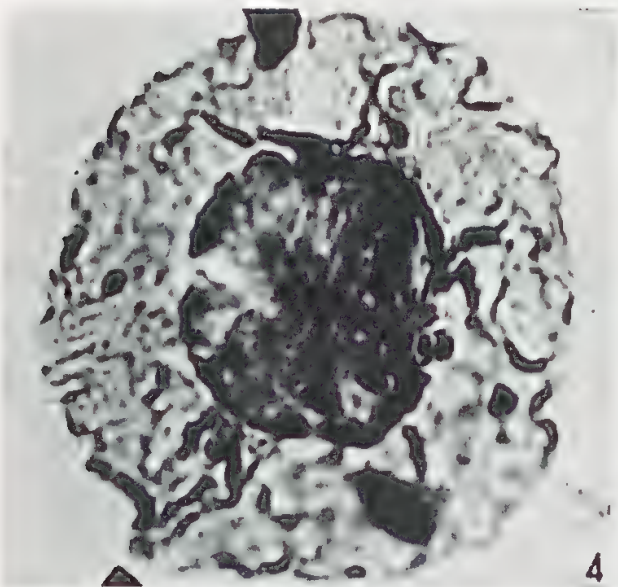
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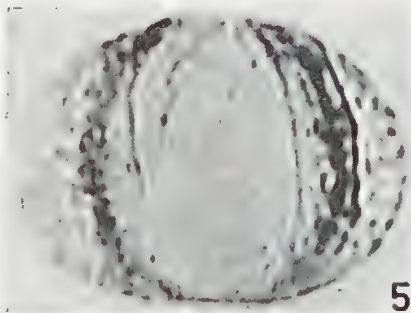
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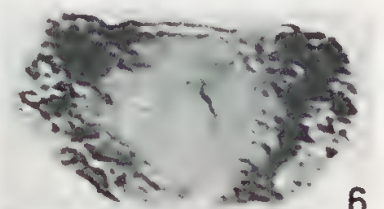
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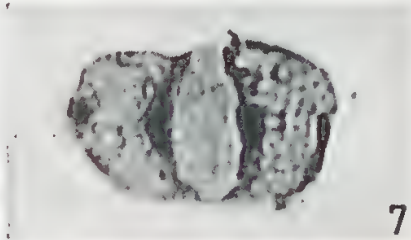
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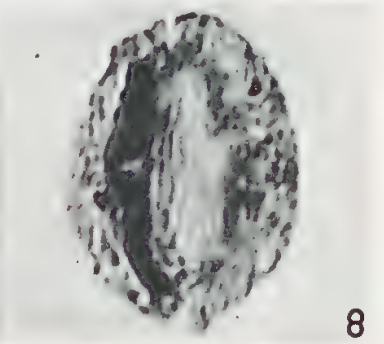
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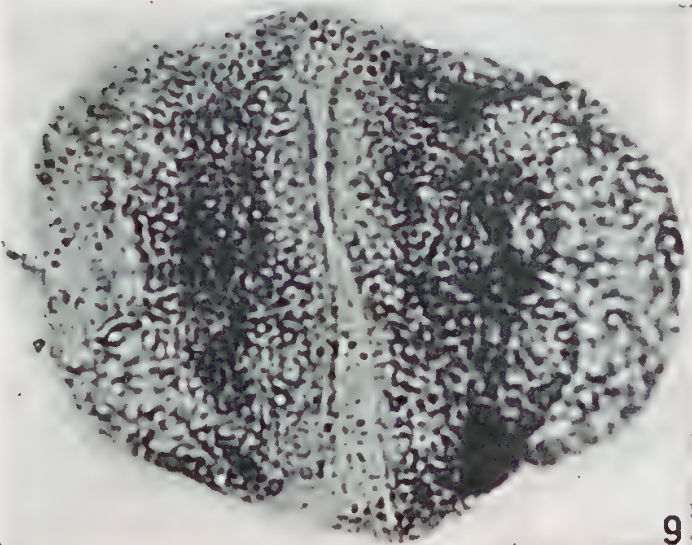
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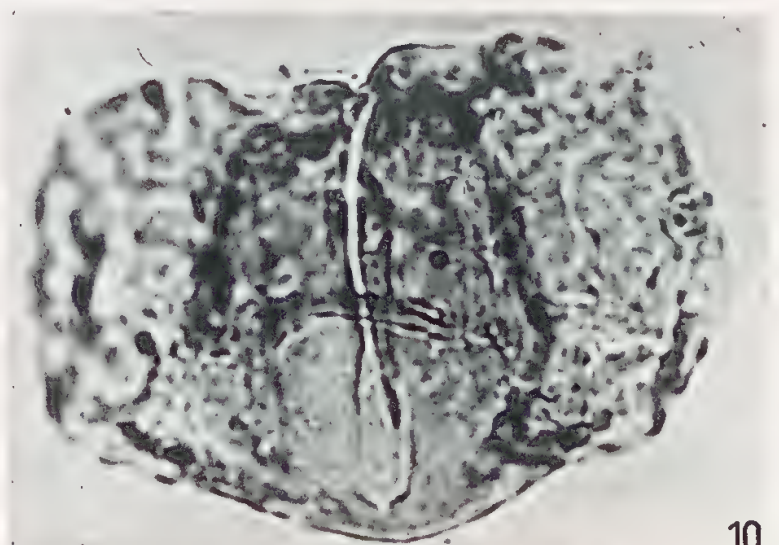
7.



8.



9.



10.

## PLATE 6

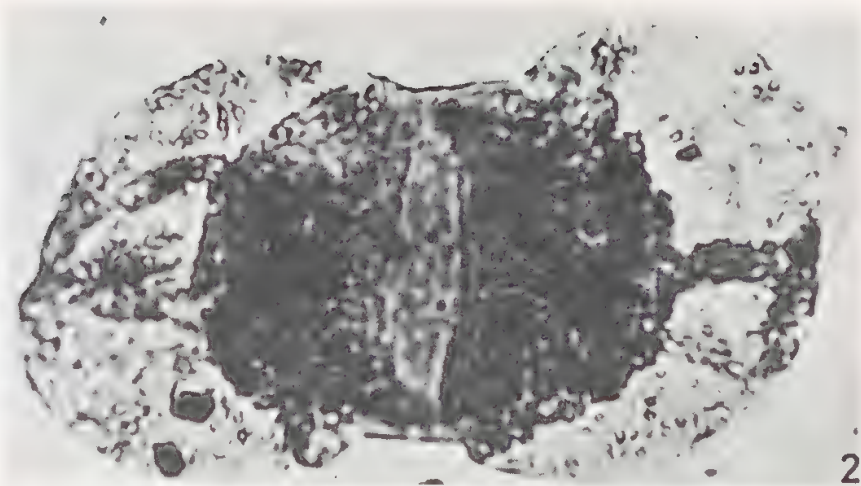
(All photographs approximately  $\times 1000$ )

- Figure 1 —*Triadispora crassa* Klaus, 1964 (proximal focus).
- Figure 2 —*Platysaccus queenslandi* de Jersey, 1962 (distal focus).
- Figure 3 —*Platysaccus queenslandi* de Jersey, 1962 (distal focus).
- Figure 4 —*Voltziaceasporites heteromorpha* Klaus, 1964 (polar view, median focus).
- Figure 5 —*Voltziaceasporites heteromorpha* Klaus, 1964 (polar view, median focus).
- Figure 6 —*Voltziaceasporites heteromorpha* Klaus, 1964 (polar view, median focus).
- Figure 7 —*Voltziaceasporites heteromorpha* Klaus, 1964 (lateral view).
- Figure 8 —*Voltziaceasporites heteromorpha* Klaus, 1964 (lateral view).

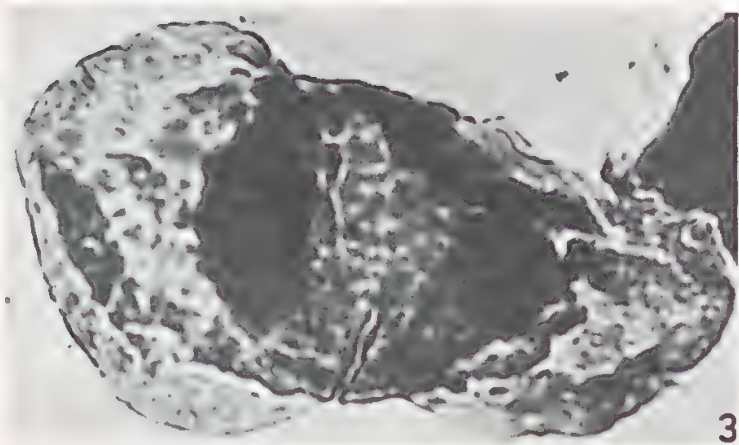




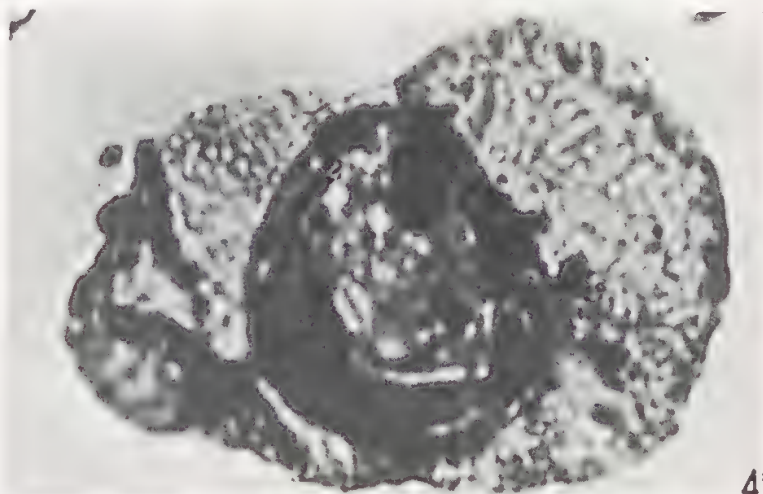
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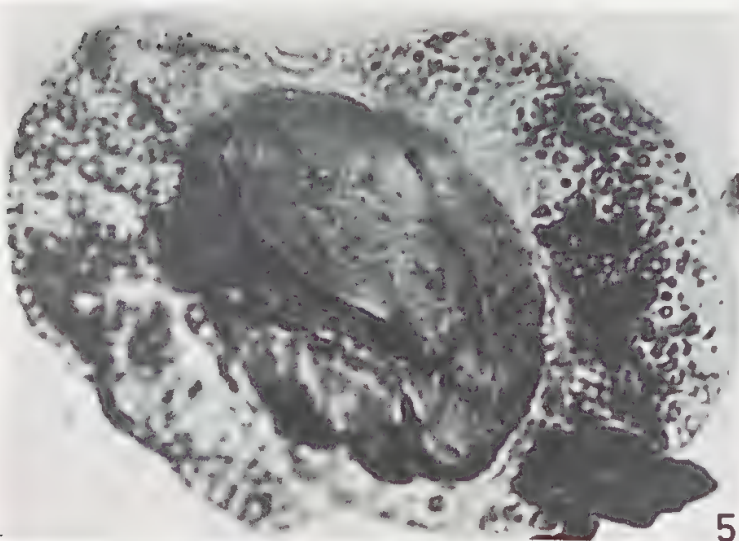
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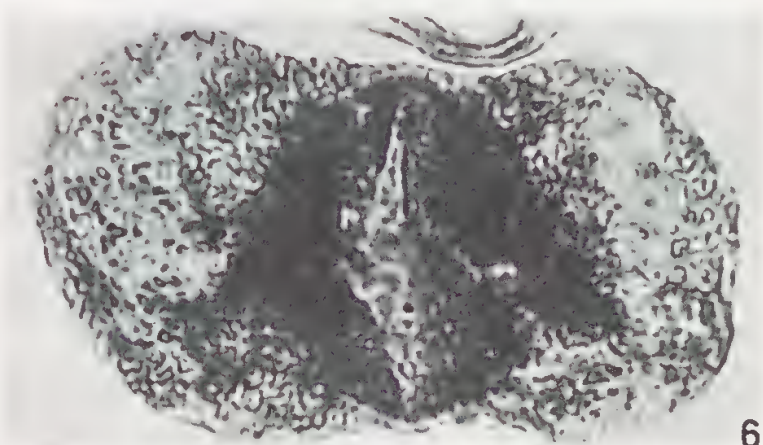
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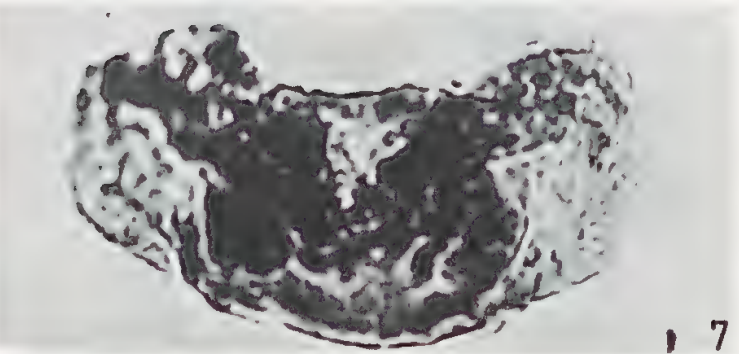
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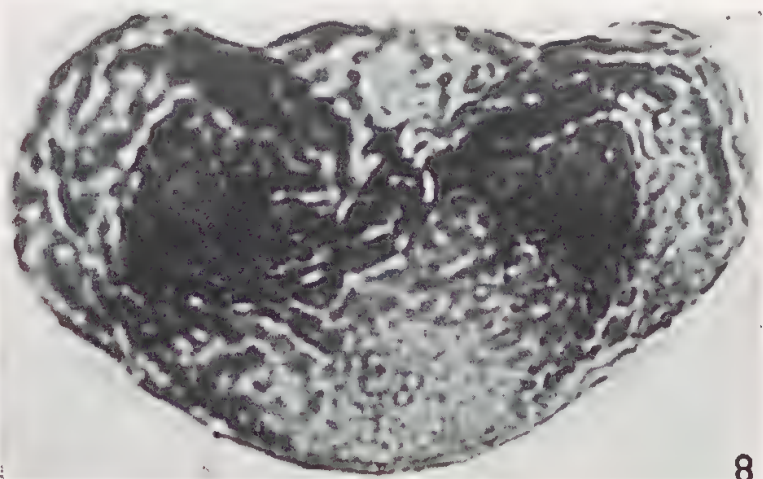
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6



7



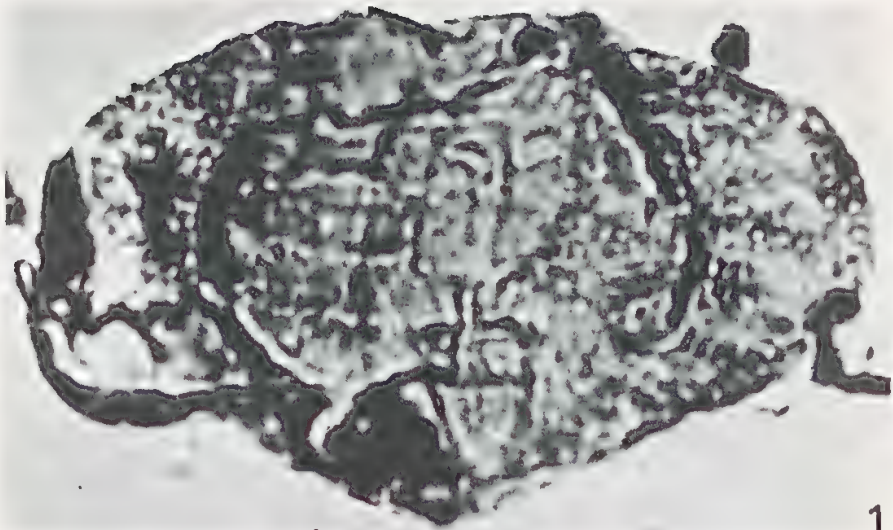
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## PLATE 7

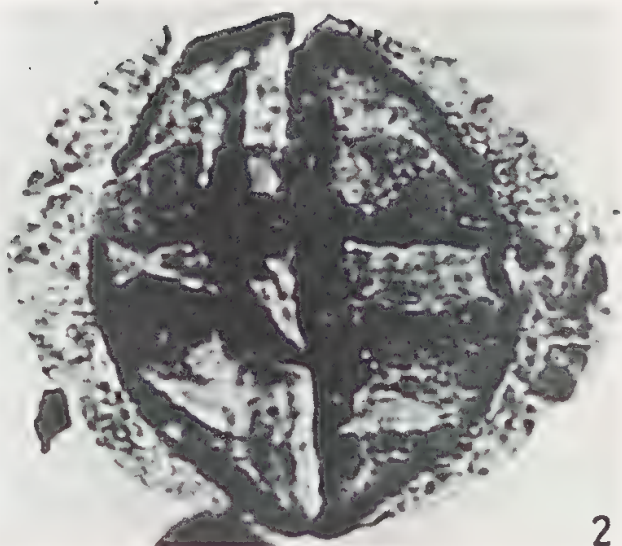
(All photographs approximately  $\times 1000$ )

- Figure 1 —*Hamiapollenites insculptus* Playford and Dettmann, 1965 (median focus).
- Figure 2 —*Striatissaccus* sp. A (median focus).
- Figure 3 —*Striatissaccus novimundi* (Jansonius) de Jersey, 1968 (proximal focus).
- Figure 4 —*Striatissaccus novimundi* (Jansonius) de Jersey, 1968 (proximal focus).
- Figure 5 —*Lueckisporites* sp. cf. *L. tattooensis* Jansonius, 1962 (proximal focus).
- Figure 6 —*Protohaploxypinus samoilovichii* (Jansonius) Hart, 1964 (proximal focus).
- Figure 7 —*Striatopodocarpites cancellatus* (Balme and Hennelly) Hart, 1963 (proximal focus).
- Figure 8 —*Striatissaccus obex* (Balme) Reinhardt and Schön, 1967 (proximal focus).





1



2



3



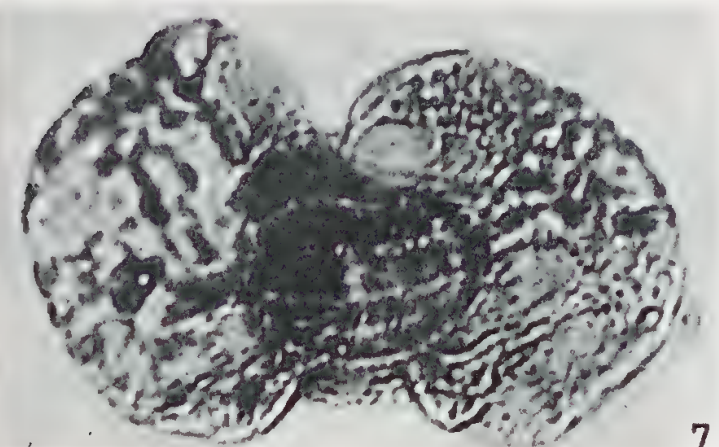
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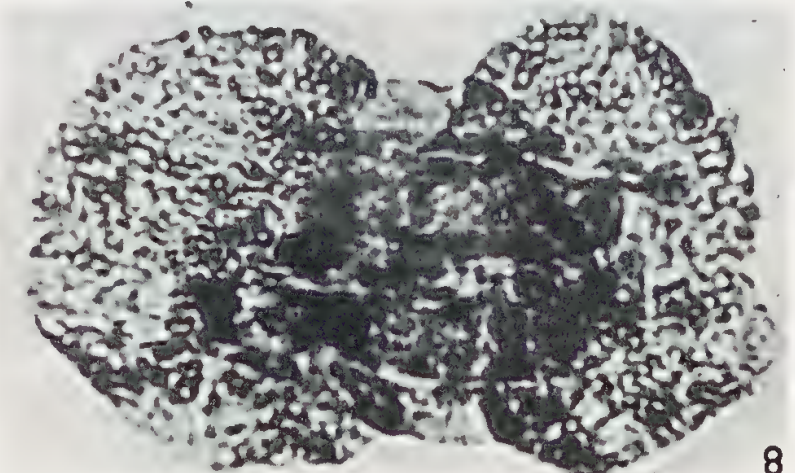
5



6



7



8

**PLATE 8**

(All photographs approximately  $\times 1000$ )

Figure 1 —*Striomonosaccites* sp. cf. *S. ovatus* Bharadwaj, 1962 (median focus—specimen with proximal face torn out).

Figure 2 —*Striomonosaccites* sp. cf. *S. ovatus* Bharadwaj, 1962 (proximal focus).

Figure 3 —*Striomonosaccites* sp. cf. *S. ovatus* Bharadwaj, 1962 (proximal focus).

Figure 4 —*Striomonosaccites* sp. cf. *S. ovatus* Bharadwaj, 1962 (proximal focus).

Figure 5 —*Protohaploxypinus limpidus* (Balme and Hennelly) Balme and Playford, 1967 (proximal focus).

Figure 6 —*Grebespora* sp. A (equatorial focus).



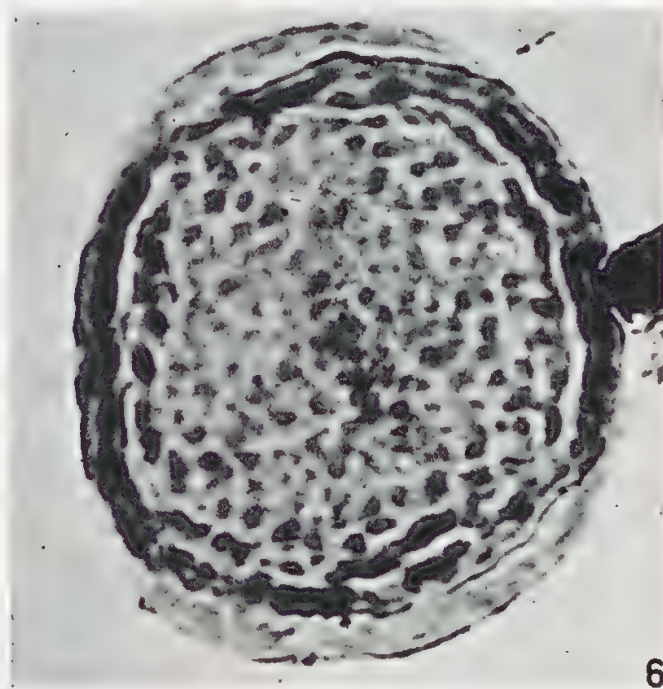
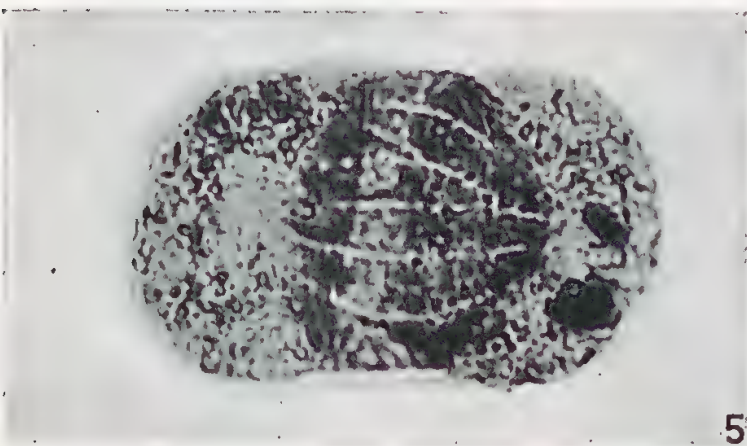
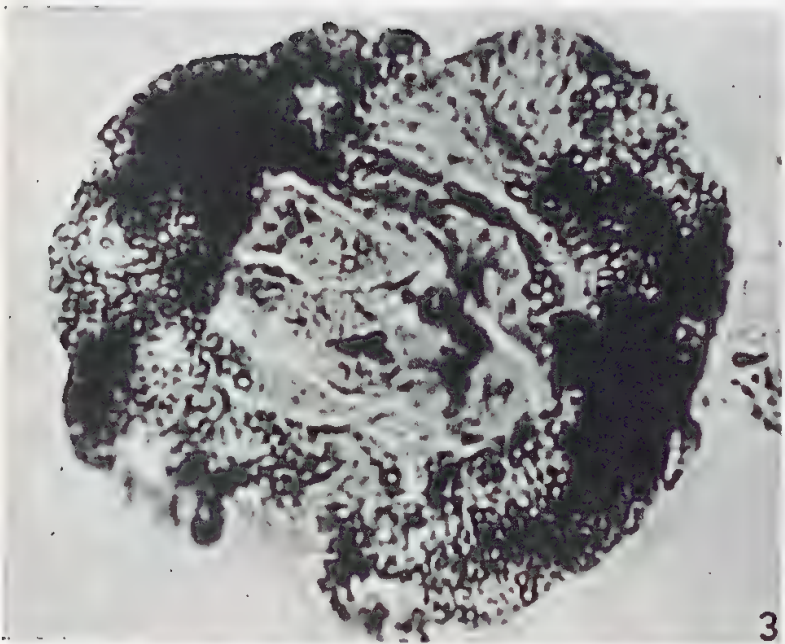
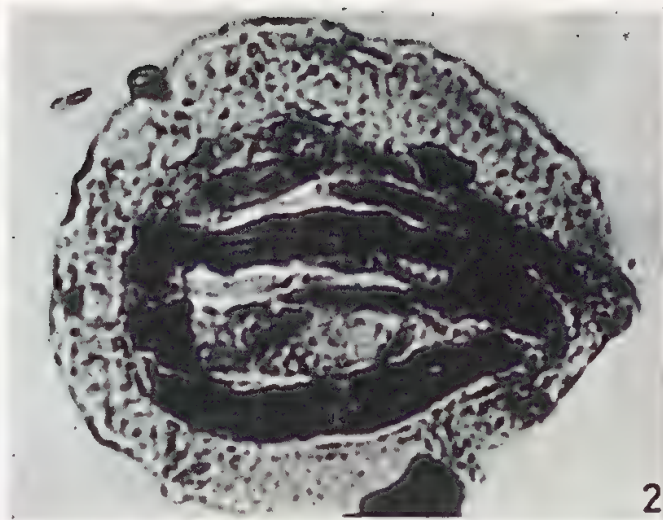
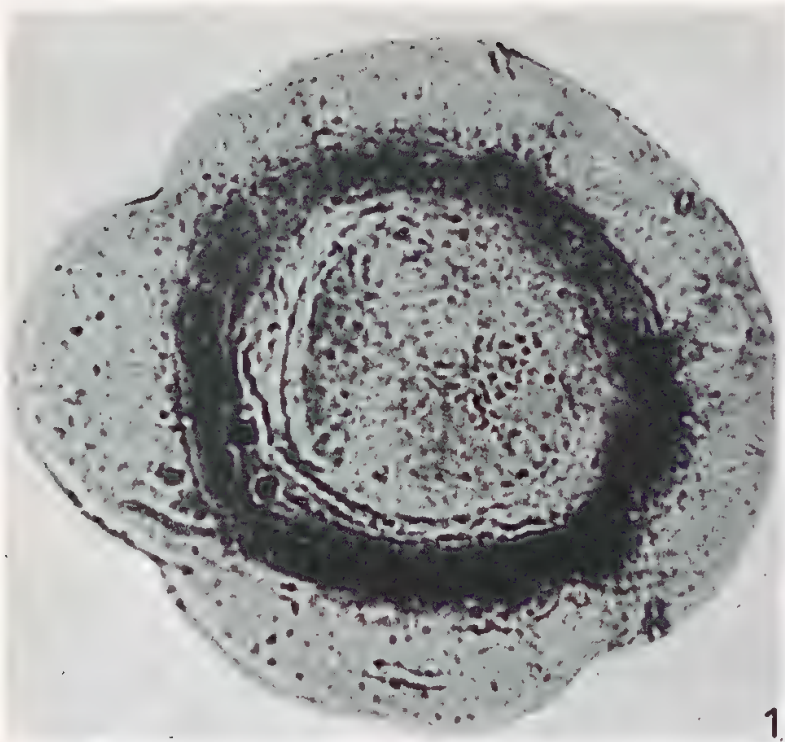


PLATE 8.

## PLATE 9

(All photographs approximately  $\times 1000$ , unless otherwise stated)

- Figure 1 —*Marsupipollenites klausii* sp. nov. (median focus).  
Figure 2 —*Marsupipollenites klausii* sp. nov. (median focus,  $\times 1500$ —  
showing fine intra-structure).  
Figure 3 —*Marsupipollenites klausii* sp. nov. (Holotype, median focus).  
Figure 4 —*Discisporites psilatus* de Jersey, 1964 (median focus).  
Figure 5 —*Discisporites psilatus* de Jersey, 1964 (median focus).  
Figure 6 —*Discisporites psilatus* de Jersey, 1964 (median focus).  
Figure 7 —*Equisetosporites steevesi* (Jansonius) de Jersey, 1968 (median  
focus).  
Figure 8 —*Cycadopites nitidus* (Balme) de Jersey, 1964 (median focus).  
Figure 9 —*Grebespora concentrica* Jansonius, 1962 (equatorial focus).  
Figure 10—*Marsupipollenites triradiatus* Balme and Hennelly, 1956  
(proximal focus).  
Figure 11—*Grebespora magna* sp. nov. (equatorial focus).  
Figure 12—*Grebespora magna* sp. nov. (Holotype, equatorial focus).  
Figure 13—"Marsupipollenites" *sinuosus* Balme and Hennelly, 1956  
(median focus).



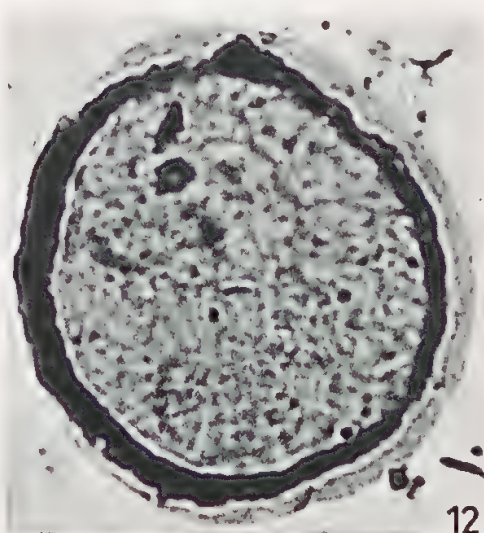
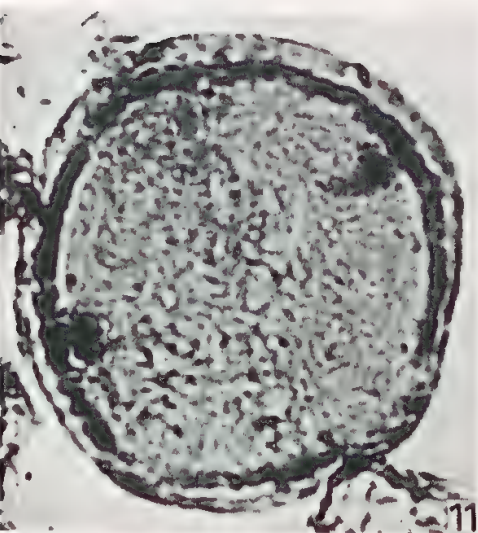
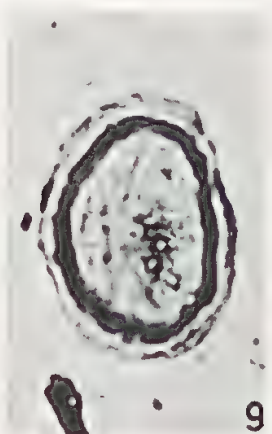
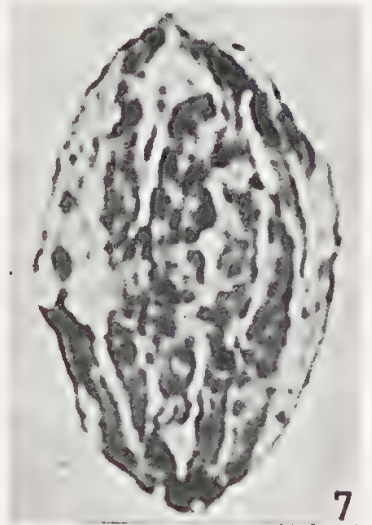
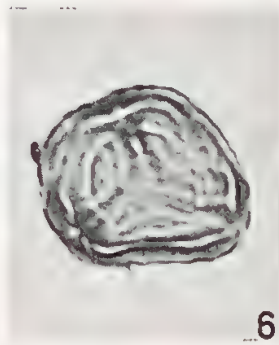
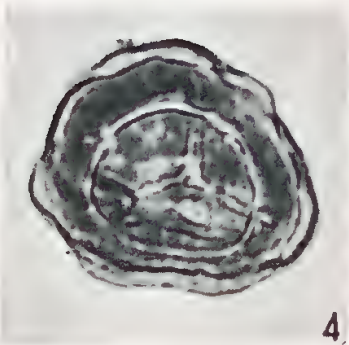


PLATE 9



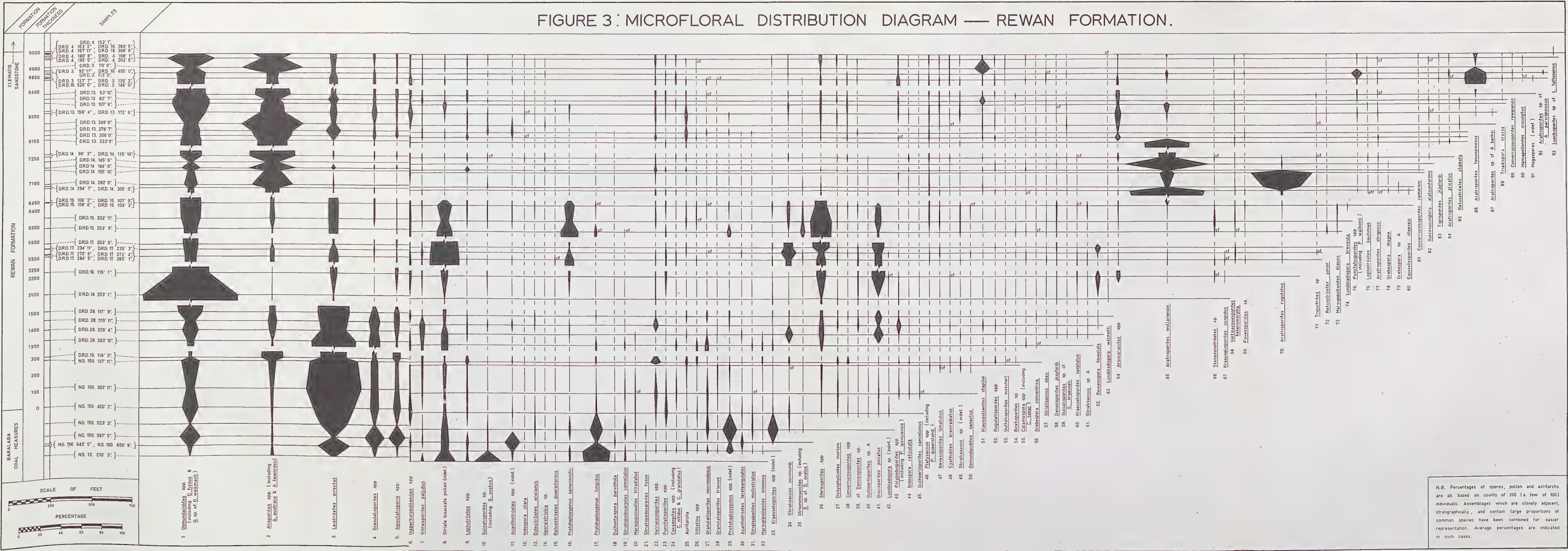








FIGURE 3: MICROFLORAL DISTRIBUTION DIAGRAM — REWAN FORMATION.









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QUEENSLAND  
DEPARTMENT OF MINES

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GEOLOGICAL SURVEY OF QUEENSLAND  
(J. T. Woods, Chief Government Geologist)

PUBLICATION No. 348  
PALAEONTOLOGICAL PAPERS, No. 22

TRIASSIC MIOSPORES FROM THE BLACKSTONE FORMATION,  
ABERDARE CONGLOMERATE AND RACEVIEW FORMATION

By N. J. de JERSEY



BRISBANE  
JUNE, 1970

5-1-70





QUEENSLAND  
DEPARTMENT OF MINES

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JUNE, 1970

Figure 1

# LOCALITY MAP

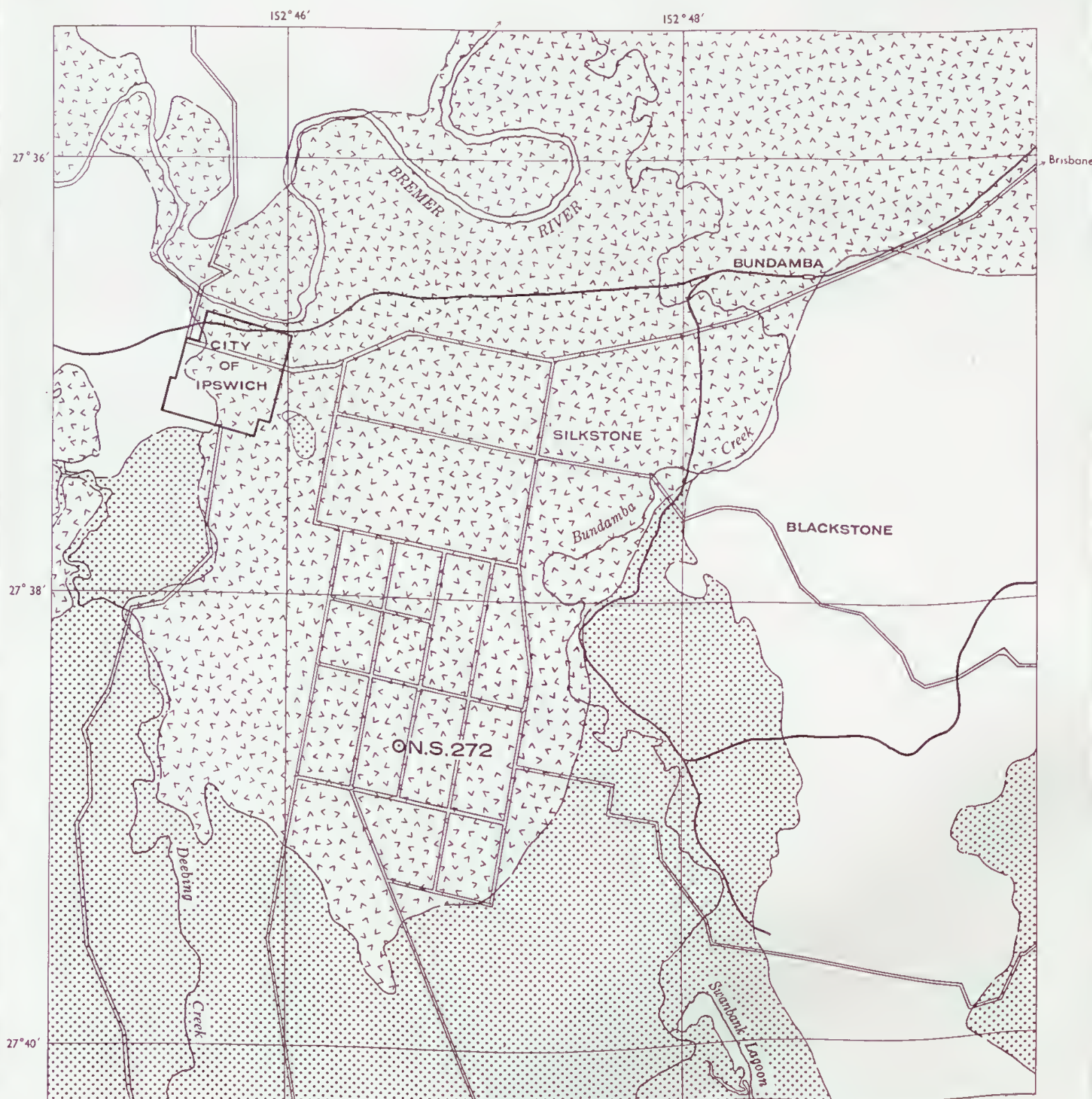
## Showing Location of N.S. 272 (Ipswich Coalfield)

Geology after Denmead, G.S.Q. Pub. 279

Scale of Miles



Ipswich Coal Measures
  Bundamba Group
  Tertiary (undiff. volcanics and sediments)



Redrawn by G. Lihou, Drafting Branch, Department of Mines, Brisbane. Jan., 1970.



# TRIASSIC MIOSPORES FROM THE BLACKSTONE FORMATION, ABERDARE CONGLOMERATE AND RACEVIEW FORMATION

by N. J. DE JERSEY  
Geological Survey of Queensland

## ABSTRACT

Triassic miospores are recorded from eighteen shale samples, from the sub-surface of the Blackstone Formation, Aberdare Conglomerate and Raceview Formation, in the Moreton Basin of south-eastern Queensland. The samples are distributed over a vertical interval of about 1250 feet, which includes the disconformable boundary between the Ipswich Coal Measures and the overlying Bundamba Group.

Microfloral assemblages from these three formations comprise 65 distinct species. Two new species are described; one of them is designated the type of a new genus, *Craterisporites*. This taxon is proposed for trilete miospores with discrete, crater-shaped distal projections. The other new species is assigned to the genus *Pustulatisporites*. Three new combinations are also proposed and the morphology and synonymy of these, and other species, are discussed.

The microfloral sequence in the section studied is discussed and illustrated by a microfloral distribution chart. Evidence on the age of the microfloras is summarized and they are compared with other Australian Triassic microfloras. A Late Triassic age (Norian or Rhaetian) is indicated for the Aberdare Conglomerate and Raceview Formation (the basal part of the Bundamba Group). The composition of assemblages from the underlying Blackstone Formation favours a Late Triassic (Karnian) age; the hiatus between the Ipswich Coal Measures and Bundamba Group is considered to be of relatively short duration. The investigation will provide a basis for microfloral correlation, in sediments of similar age, elsewhere in the Moreton Basin.

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## INTRODUCTION

Sediments of Triassic age are extensively developed in the Moreton Basin of south-eastern Queensland. Their stratigraphy has been studied in some detail in the area of the Ipswich coalfield, where two major units are recognized — the Ipswich Coal Measures and Bundamba Group. These Groups are separated by a disconformity, as the Aberdare Conglomerate, at the base of the Bundamba Group, was deposited on the eroded surface of the Blackstone Formation, the uppermost formation of the Ipswich Coal Measures.

The Ipswich-Bundamba sequence, as developed in the Ipswich area, constitutes a reference succession, with which to correlate other developments of Triassic strata in the Moreton Basin. Sediments in this succession

are all of non-marine origin; they contain plant fossils, which provide material for correlation studies. Plant macrofossils from the Ipswich Coal Measures were described by Jones and de Jersey (1947). More recently, plant microfossils have been described from the Ipswich Coal Measures and Bundamba Group (de Jersey, 1962, 1964).

Although much useful information has been obtained from study of macrofossils, plant microfossils, particularly the smaller spores and pollen grains (miospores), are likely to find more extensive application in correlation studies in these sediments. This is because of the wider distribution of the latter, especially in borehole samples which, in many parts of the Ipswich-Bundamba sequence, yield few or fragmentary macrofossils.

The primary purpose of the present investigation has been to establish more precisely the differences between microfloras from the Ipswich Coal Measures and those of the overlying Bundamba Group, so as to provide a basis for correlation with sediments in other parts of the Moreton Basin. To do so it was, firstly, necessary to study assemblages from shale samples, from within the Ipswich Coal Measures, as the previous study of the Ipswich microflora (de Jersey, 1962) was based on samples from coal seams. This is because shales, in general, are likely to yield more diverse assemblages than those from the associated coal seams, and so provide a more comprehensive picture of the microfloral sequence.

An additional reason for further study of assemblages from the Ipswich-Bundamba sequence has been to apply improved techniques in processing the shale samples. In studies of Triassic microfloras from the Bowen Basin (de Jersey and Hamilton, 1967; de Jersey, 1968) it was found that the yield of plant microfossils was considerably enhanced and the proportion of opaque carbonaceous matter appreciably reduced, by specific gravity separation, after initial treatment with hydrofluoric acid. As such opaque debris also bulks largely in the initial maceration residues, from the Ipswich-Bundamba sediments, it seemed likely that similar application of specific gravity separation would also improve the yields of miospores in samples from the latter sequence.

Accordingly, as a first step in this investigation of the Ipswich-Bundamba sequence, assemblages from shales in the Blackstone Formation, at the top of the succession in the Ipswich Coal Measures, have been studied and compared with those from the overlying Aberdare Conglomerate and Raceview Formation of



the Bundamba Group. By selecting samples from N.S. 272, a borehole drilled in the southern part of the Ipswich Coalfield (see locality map — Figure 1), it was possible to study assemblages showing the microfloral distribution in these formations, in one continuously cored vertical sequence. The present investigation has thus provided data for direct comparison of microfloras below, and above, the Ipswich-Bundamba boundary. In addition it provides information on the morphology of the species, supplementary to previous papers, and also further evidence on the age of the sediments in this part of the sequence.

### STRATIGRAPHIC DISCUSSION

As indicated above, the investigation has been based on samples from N.S. 272, a Mines Department drill hole located in the Ripley Road area, in the southern part of the Ipswich coalfield (see locality map — Figure 1). This hole was drilled during 1963 to test the coal seams of the Blackstone Formation, the uppermost formation of the Ipswich Coal Measures. It was cored almost continuously to a total depth of 2466 feet 3 inches. Core recovery was 92.7 per cent of the total thickness of strata penetrated; loss of core was greatest in Tertiary rocks at the top of the sequence.

The Tertiary succession, consisting of basalt and interbedded sediments, extends from the surface to an approximate depth of 446 feet. It is underlain unconformably by the Ripley Road Sandstone, the uppermost of three stratigraphic units of the Bundamba Group defined by Staines (1964). The base of the Ripley Road Sandstone is located at a depth of 1183 feet in this hole (Staines, 1964, p. 34). It consists dominantly of massive sandstone and is conformably underlain by the Raceview Formation, which comprises interbedded sandstone, siltstone, shale and a few thin coal seams. Below this, again conformably, is the Aberdare Conglomerate, which in N.S. 272 is represented by the section between the depths of 1622 feet and 1694 feet. Disconformably below the Aberdare Conglomerate, the Blackstone Formation extends to a depth of 2452 feet; the hole reached total depth in sediments assigned to the underlying Cooneana Formation.

Staines (1964, p. 34) has designated core from this hole to constitute the type sections of the Ripley Road Sandstone and Raceview Formation. The complete core recovered from N.S. 272 is stored in the Department of Mines Core Library, Redbank. In the current investigation samples of shale were selected at intervals through the sequence, from the basal part of the Blackstone Formation to the top of the Raceview Formation, to provide material for palynological study. Depths of the samples selected ranged from 1183 feet 7 inches to 2440 feet 5 inches in N.S. 272. Of these, eleven from the Blackstone Formation, one from the Aberdare Conglomerate and six from the Raceview Formation gave significant yields of plant microfossils. The stratigraphic levels of these samples are indicated in the Microfloral Distribution Chart (Figure 2), which

also illustrates the lithology of the Raceview Formation and of the underlying section, to total depth. It should be noted that the section in Figure 2 represents vertical thicknesses of the sediments; dips in this section range from about 10° to 20°, the average dip being about 13°. The vertical intervals indicated are thus slightly in excess of true stratigraphic thicknesses.

### PROCESSING OF SAMPLES

The samples examined consisted of light or dark grey shale; some of them contained visible fragments of carbonaceous plant material. Laboratory techniques employed were similar to those applied in processing samples from the Triassic of the Bowen Basin (de Jersey and Hamilton, 1967, p. 2; de Jersey, 1968, p. 3). The initial maceration residues (after treatment of the samples with hydrofluoric and hydrochloric acids, followed by mild oxidation) contained large proportions of opaque carbonaceous matter. Specific gravity separation in zinc chloride or zinc bromide solution proved effective in reducing markedly the proportion of this opaque matter in the final residue, from which permanent microslides were prepared.

In most cases the microslides were sufficiently rich in miospores to enable at least 200 specimens to be counted, in order to provide a basis for percentage distribution studies. The preservation of miospores in assemblages from the Raceview Formation was, in general, better than in assemblages from the underlying sediments. In addition, spores and pollen grains in the Blackstone assemblages showed a general tendency to be more compressed than those in assemblages from the higher formations.

In accordance with the writer's previous practice figured specimens are located by the stage co-ordinates of a Carl Zeiss GFL Microscope. In addition to the specimen co-ordinates, co-ordinates of a reference point, arbitrarily selected as the lower right hand corner of the cover glass, are recorded in the text for each figured specimen. With this information the specimens can be readily located by means of any microscope equipped with a mechanical stage. Microslides prepared during the investigation are stored in the collection of the Palynology Section, Geological Survey of Queensland.

### SYSTEMATIC DESCRIPTIONS

As in a recent paper on assemblages from the Rewan Formation (de Jersey, 1970), genera recorded below are arranged, in most cases, on the basis of the suprageneric classification of Potonié (1966). Some difficulties are apparent in the application of this classification; for example, the genus *Cadargasporites* is difficult to place, as it includes species representative of different suprageneric groups. However, adoption of Potonié's system has enabled uniformity of arrangement of genera, in relation to the previous paper. A further review of the grouping of the genera concerned is deferred until a more widely accepted system of classification is developed.



|            |                                                        |
|------------|--------------------------------------------------------|
| Anteturma  | SPORITES H. Potonié, 1893                              |
| Turma      | TRILETES Reinsch <i>emend.</i> Dettmann, 1963          |
| Subturma   | AZONOTRILETES Lubert <i>emend.</i> Dettmann, 1963      |
| Infraturma | LAEVIGATI Bennie & Kidston <i>emend.</i> Potonié, 1956 |
| Genus      | CALAMOSPORA Schopf, Wilson & Bentall, 1944             |

*Type Species*:— *Calamospora hartungiana* Schopf, in Schopf, Wilson & Bentall, 1944.

*Calamospora tener* (Leschik) de Jersey, 1962

*Distribution*:— Keuper of Switzerland (Leschik, 1955); Karnian of Austria (Klaus, 1960); Triassic of Ipswich Coal Measures (de Jersey, 1962, this paper); Jurassic of Great Britain (Couper, 1958); Lower Keuper of West Germany (Mädler, 1964); Middle and Upper Triassic and Lower Jurassic of East Germany (Schulz, 1966); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970).

Genus DICTYOPHYLLIDITES Couper *emend.*

Dettmann, 1963

*Type Species*:— *Dictyophyllidites harrisii* Couper, 1958.

*Dictyophyllidites mortoni* (de Jersey) Playford & Dettman, 1965

*Remarks*:— This species is widely distributed in Lower Mesozoic sediments, in Queensland.

*Distribution*:— Jurassic of Walloon Coal Measures, Marburg Sandstone (de Jersey, 1959, 1963); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Ipswich Coal Measures (de Jersey, 1962); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970); Triassic of Tasmania (Playford, 1965); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, this paper).

Genus LEIOTRILETES (Naumova)  
Potonié & Kremp, 1954

*Type Species*:— *Leiotriletes sphaerotriangulus* Loose) Potonié & Kremp, 1954.

*Leiotriletes directus* Balme & Hennelly, 1956

*Remarks*:— Spores of this simple generalized type are widely distributed in the Permian, Triassic and Jurassic of Australia.

Genus STEREISPORITES Pflug, *emend.* de Jersey, 1964

*Type Species*:— *Stereisporites stereoides* (Potonié & Venitz) Pflug, 1953.

*Stereisporites antiquasporites* (Wilson & Webster) Dettmann, 1963

Plate 1, Figure 1:

*Figured Specimen*:— Slide S2209, stage co-ordinates 10.2, 93.3; diameter 30 microns. Co-ordinates of lower right hand corner of cover glass 25.5, 82.4.

*Locality*:— N.S. 272, 2389 ft., 8 ins. (Blackstone Formation).

*Distribution*:— Widely distributed in Mesozoic and Tertiary sediments. Queensland records: Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964; Hill, Playford and Woods, 1965; this paper); Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Rewan Formation (de Jersey, 1970); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds, Mount Morgan (Playford and Cornelius, 1967).

*Stereisporites perforatus* Leschik, 1955

Plate 1, Figure 2

*Figured specimen*:— Slide S2208, stage co-ordinates 24.0, 74.3; diameter 33 microns. Co-ordinates of lower right hand corner of cover glass, 27.3, 73.7.

*Locality*:— N.S. 272, 2389 ft., 8 in. (Blackstone Formation).

*Remarks*:— Leschik's description of *Stereisporites perforatus* (Leschik, 1955, p. 10) was preceded by the description of specifically identical spores as *Sporites cicatricosus* Rogalska (Rogalska, 1954, pp. 38, 44). Concerning the name *Sporites*, Schopf, Wilson and Bentall state (1944, p. 60): "The names *Sporites* (H. Potonié, 1892), *Pollenites* and *Sporonites* (R. Potonié, 1931) cannot be regarded as having systematic value. Forms listed in these groups have no essential biological features in common, no type species are recognized, and no systematic treatment is feasible on this basis." Consequently the combination *Sporites cicatricosus* contravenes Article 43 of the International Code of Botanical Nomenclature (1966) which provides that the name of a taxon below the rank of genus is not validly published unless the name of the genus to which it is assigned is validly published at the same time or was validly published previously. Accordingly the later, but validly proposed combination *Stereisporites perforatus* Leschik is the correct name of the species. Playford and Dettmann (1965; p. 134) also considered *Stereisporites perforatus* to be the correct designation for this species.

*Distribution*:— Middle Keuper of Switzerland (Leschik, 1955); Liassic of Poland (Rogalska, 1954, 1956); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Late Triassic of Tasmania (Playford, 1965); Middle Keuper of East Germany, Schulz, 1966); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Triassic of Blackstone Formation, Raceview Formation (Hill, Playford, and Woods, 1965; this paper); Rhaeto-Liassic of Canada (McGregor, 1965).



*Stereisporites tenuis* (de Jersey) de Jersey, 1964

*Distribution*:— Jurassic of Walloon Coal Measures, Marburg Sandstone (de Jersey, 1959, 1963); Triassic of Ipswich Coal Measures, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1962, 1964); Late Triassic and early Jurassic of Victoria Land, Antarctica (Norris, 1965).

*Stereisporites* sp. A

Plate 1, Figure 3

*Description*:— Amb convexly subtriangular to subcircular. Diameter (based on 4 measured specimens) 31 to 41 microns. Trilete; laesurae, straight or slightly sinuous, length two-thirds to three-quarters spore radius. Exine 1 to 2 microns thick, smooth proximally. Distal surface has a low, faintly scabrate polar thickening which is developed to within about 7 to 8 microns of equator; low radially disposed elevations extend from outer margins of thickening to equator and enclose elliptical to subcircular lumina, about 10 to 12 in number, 3 to 5 microns in maximum diameter.

*Figured specimen*:— Slide S2215, stage co-ordinates 21.8, 94.4; diameter 41 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 84.4.

*Locality*:— N.S. 272, 2289 ft., 8 ins. (Blackstone Formation).

*Remarks*:— These spores are of similar general construction to *Stereisporites perforatus* Leschik but differ from that species in having only about half as many lumina on the distal surface. (The number of lumina per specimen is 10 to 12, compared with 21 to 25 in *S. perforatus*). Insufficient specimens are available to warrant formal taxonomic treatment. In having a relatively small number of lumina *Stereisporites* sp. A resembles *Stereisporites* sp. (No. 322) recorded by Schulz (1966, Table 5c) from the Middle Keuper of East Germany. Six lumina are shown in the line drawing of the latter species.

*Distribution*:— Blackstone Formation (this paper).

|               |                                                           |
|---------------|-----------------------------------------------------------|
| Infraturma    | APICULATI Bennie & Kidston <i>emend.</i><br>Potonié, 1956 |
| Subinfraturma | VERRUCATI Dybová & Jachowicz,<br>1957                     |
| Genus         | CLAVATRILETES Herbst, 1965                                |

*Type species*:— *Clavatriletes hammenii* Herbst, 1965.  
*Clavatriletes* sp. cf. *C. hammenii* Herbst, 1965

Plate 1, Figures 4, 5, 6

*Figured specimen* (Plate 1, Figure 6):— Slide S2133, stage co-ordinates 16.0, 87.7; diameter 63 microns. Co-ordinates of lower right hand corner of cover glass 27.5, 83.5.

*Locality*:— N.S. 272, 1207 ft., 10 in. (Raceview Formation).

*Figured specimen* (Plate 1, Figure 4, 5 — proximal, equatorial foci):— Slide S2136, stage co-ordinates 24.0, 89.1; diameter 59 microns. Co-ordinates of lower right hand corner of cover glass 27.8, 84.4.

*Locality*:— N.S. 272, 1207 ft., 10 in. (Raceview Formation).

*Remarks*:— These spores are similar to specimens recorded as *Clavatriletes* sp. cf. *C. hammenii* from the Moolayember Formation (de Jersey and Hamilton, 1967, pp. 6, 7) and Clematis Sandstone (de Jersey, 1968, p. 5). Final decision on their identification with *C. hammenii* must await more detailed knowledge of variation in the South American species. The distinctive clavate sculpture is evident in the specimens figured; one of the figures (Plate 1, Figure 4) illustrates the absence of clavate sculpture in the proximal contact area, which is smooth or faintly punctate.

Regarding preservation, the specimens fall into two groups, comprising (1) specimens from the Raceview Formation which have a somewhat globose appearance and in which the projections appear to be distinctly separated (Plate 1, Figures 4-6 of this paper) and (2) more compressed specimens from the Blackstone Formation, Moolayember Formation (de Jersey and Hamilton, 1967 pl. 2, fig. 6) and Clematis Sandstone (de Jersey, 1968, pl. 1, fig. 7) in which the projections appear more densely packed, particularly in the equatorial region. It is considered that these differences in appearance may be explained by greater compression of the spore exines, in the case of specimens from the older formations, brought about by the increased thicknesses of overlying sediments.

*Distribution*:— Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968) Triassic of Raceview Formation, Blackstone Formation (this paper). *Clavatriletes hammenii* was described by Herbst (1965, p. 144) from the Upper Triassic Los Rastros Formation, Argentina.

#### Genus CONVERRUCOSISPORITES

Potonié & Kremp, 1954

*Type species*:— *Converrucosisporites triquetrus* (Ibrahim) Potonié & Kremp, 1954.  
*Converrucosisporites cameroni* (de Jersey) Playford & Dettman, 1965)

*Distribution*:— Triassic of Ipswich Coal Measures, Bundamba Group (de Jersey, 1962, 1964, this paper); Triassic and Jurassic of Leigh Creek Coal Measures (Playford and Dettman, 1965); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970).

#### Genus CRATERISPORITES gen. nov.

*Generic diagnosis*:— Trilete, azonate miospores. Amb subcircular or convexly subtriangular. Proximal exine smooth. Distal and equatorial exine with discrete sculptural elements, consisting dominantly of ring-shaped projections, each formed by a low outer ridge which encloses an area of unthickened exine.



*Type species (here selected):— Craterisporites rotundus* sp. nov., described below.

*Remarks:*— The generic name refers to the crater-like shape of the distal projections. The construction of these projections serves to differentiate *Craterisporites* from other apiculate genera, such as *Anapiculatisporites* Potonié and Kremp, 1954, *Cycloverrurites* Schulz, 1964 and *Verrucosisporites* Ibrahim *emend.* Smith and Butterworth, 1967, in all of which the conate and verrucose projections are without central depressions. Foveolate genera, such as *Brochotriletes* Naumova, 1953, *Foveosporites* Balme, 1957 and *Perforosporites* Scott and Rouse, 1961, differ in having negative sculpture, consisting of foveolate depressions in the exine, and are thus distinguishable from *Craterisporites*, in which the sculpture is positive, being formed by raised projections.

*Craterisporites rotundus* sp. nov.

Plate 1, Figures 7, 8, 9

*Diagnosis:*— Amb subcircular or convexly subtriangular. Diameter (based on 25 measured specimens) 33 to 53 microns. Trilete; laesurae straight, with lips thickened for a width of about 1.5 to 2 microns, extend to, or almost to, equator. Proximal exine smooth. Distal and equatorial sculpture consists dominantly of ring-shaped projections, each formed by an outer ridge of subcircular or broadly oval outline and rounded in cross-section, enclosing a subcircular area of unthickened exine. Overall basal diameter of projections from about 2.5 to 7 microns, height 1.5 to 2 microns, width of outer ridge 1 to 2.5 microns. Projections fairly regularly distributed, from 1 to 4 microns apart. Projections relatively uniform in size within each specimen; a small proportion of them may be either incomplete (crescent-shaped) or solid (verrucose). Exine (apart from sculptural elements) about 1 micron in thickness.

*Holotype* (Plate 1, Figure 8):— Slide S2159, stage co-ordinates 18.7, 93.3; diameter 37 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 83.6.

*Locality:*— N.S. 272, 1600 ft., 2 in. (Raceview Formation).

*Figured specimen* (Plate 1, Figure 7):— Slide S2221, stage co-ordinates 17.5, 91.8; diameter 41 microns. Co-ordinates of lower right hand corner of cover glass 26.2, 80.4.

*Locality:*— N.S. 272, 2440 ft., 5 in. (Blackstone Formation).

*Figured specimen* (Plate 1, Figure 9):— Slide S2161, stage co-ordinates 15.9, 85.5; diameter 43 microns. Co-ordinates of lower right hand corner of cover glass 27.2, 79.4.

*Locality:*— N.S. 272, 1600 ft., 2 in. (Raceview Formation).

*Variation:*— The type of variation most readily apparent is in the size of the distal projections. These are fairly uniform in size within each specimen, but there is appreciable variation among the specimens

studied. The holotype (Plate 1, Figure 8) has projections of intermediate size; the other illustrations depict specimens with smaller (Plate 1, Figure 9) and larger (Plate 1, Figure 7) projections. There is also some variation in the shape of the projections, a variable, but minor proportion of which may be either solid (verrucose) or incomplete (crescent-shaped in basal outline). Gradation exists between these extreme examples. Finally, the projections, although discrete and fairly regularly distributed, show some variation in density of spacing, from well separated (Plate 1, Figure 8) to more densely packed (Plate 1, Figure 9).

*Distribution:*— Blackstone Formation, Aberdare Conglomerate, basal Raceview Formation (this paper).

Subinfraturma NODATI Dybová & Jachowicz, 1967

Genus ACANTHOTRILETES Naumova *emend.* Potonié & Kremp, 1954

*Type Species:*— *Acanthotriletes ciliatus* (Knox) Potonié & Kremp, 1954.

*Acanthotriletes bradiensis* Playford, 1965

*Distribution:*— Late Triassic of Tasmania (Playford, 1965); Triassic of Blackstone Formation (Hill, Playford and Woods, 1965).

Genus ANAPICULATISPORITES  
Potonié & Kremp, 1954

*Type species:*— *Anapiculatisporites isselburgensis* Potonié & Kremp, 1954

*Anapiculatisporites pristidentatus* Reiser & Williams, 1969

Plate 4, Figure 9

*Figured specimen:*— Slide S2159, stage co-ordinates 11.5, 91.0; diameter 43 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 83.6.

*Locality:*— N.S. 272, 1600 ft., 2 in. (Raceview Formation).

*Remarks:*— This species has recently been described from Jurassic sediments of the Surat Basin (Reiser and Williams, 1969, p. 4). Specimens recorded here conform closely to the description and illustrations of those authors; the stratigraphic range of the species is thus extended into the Triassic.

*Distribution:*— Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (Reiser and Williams, 1969); Blackstone Formation, Aberdare Conglomerate, Raceview Formation (this paper).

Genus APICULATISPORIS Potonié & Kremp, 1956

*Type species:*— *Apiculatisporis aculeatus* (Ibrahim) Potonié, 1956

*Apiculatisporis globosus* (Leschik) Playford & Dettmann, 1965

Plate 2, Figure 1

*Figured specimen:*— Slide S2162, stage co-ordinates 20.5, 86.0; diameter 58 microns. Co-ordinates of lower right hand corner of cover glass 28.1, 76.6.

*Locality:*— N.S. 272, 1600 ft., 2 in. (Raceview Formation).



*Distribution*:— Middle Keuper of Switzerland (Leschik, 1955); Liassic of Sweden (Nilsson, 1958); Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965); Triassic of Blackstone Formation, Raceview Formation (Hill, Playford and Woods, 1965; this paper).

Genus LOPHOTRILETES (Naumova)

Potonié & Kremp, 1954

*Type species*:— *Lophotriletes gibbosus* (Ibrahim) Potonié & Kremp, 1954.

*Lophotriletes* sp. cf. *L. bauhinae* de Jersey & Hamilton, 1967

Plate 2, Figure 3

*Figured specimen*:— Slide S2198, stage co-ordinates 13.0, 98.0; diameter 48 microns. Co-ordinates of lower right hand corner of cover glass 27.1, 82.0.

*Locality*:— N.S. 272, 1925 ft., 2 in. (Blackstone Formation).

*Remarks*:— The specimen figured resembles *Lophotriletes bauhinae* in overall size, general sculptural pattern and in the presence of proximal thickenings adjacent to the laesurae. However, it differs from specimens of that species (from the Triassic of the Bowen Basin) in having appreciably larger sculptural elements (coni and spinae 2 to 3 microns in height, compared with about 1.5 microns in *L. bauhinae*). For this reason it is compared, rather than identified, with that species. It is the only specimen of this type observed in the present investigation.

Genus OSMUNDACIDITES Couper, 1953

*Type species*:— *Osmundacidites wellmanii* Couper, 1953.

*Remarks*:— Species of *Osmundacidites* are long-ranged; their distribution has little stratigraphic value, within the Triassic. No attempt has been made to achieve specific differentiation of the majority of specimens of this genus (many of them poorly preserved), apart from those assigned to *Osmundacidites parvus* and *O. wellmanii*, recorded below.

*Osmundacidites parvus* de Jersey, 1962

*Distribution*:— Triassic of Blackstone Formation (de Jersey, 1962, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b).

*Osmundacidites wellmanii* Couper, 1953

*Distribution*:— Widely distributed in Mesozoic sediments. Queensland records: Jurassic of Marburg Sandstone (de Jersey, 1963); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds, Queensland (Playford and Cornelius, 1967); Triassic of Ipswich Coal Measures, Bundamba

Group (de Jersey 1964, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967).

Genus PUSTULATISPORITES Potonié & Kremp, 1954

*Type species*:— *Pustulatisporites pustulatus* Potonié & Kremp, 1954.

*Pustulatisporites blackstonensis* sp. nov.

Plate 2, Figures 2, 4

*Diagnosis*:— Trilete miospores. Amb subcircular, equatorial outline uneven, due to development of projections. Diameter (based on 8 measured specimens) 43 to 61 microns. Laesurae straight, inconspicuous, without development of lips, length about half to three-quarters spore radius. Distal and equatorial exine with large, discrete, verruca-like projections, basal outline subcircular to semicircular or subcrescentic; in cross-section flat-topped or gently rounded. Basal diameter of projections 5 to 10 microns, height about 3 microns, about 3 to 7 microns apart. Proximal exine and remainder of exine, between projections smooth or scabrate. Exine (apart from projections) about 1 to 2 microns in thickness, may develop folds in equatorial region.

*Holotype* (Plate 2, Figure 2):— Slide S2221, stage co-ordinates 23.8, 87.4; diameter 53 microns. Co-ordinates of lower right hand corner of cover glass 26.2, 80.3.

*Locality*:— N.S. 272, 2440 ft., 5 in. (Blackstone Formation).

*Figured specimen* (Plate 2, Figure 4):— Slide S2222, stage co-ordinates 23.2, 96.4; diameter 56 microns. Co-ordinates of lower right hand corner to cover glass 25.9, 82.1.

*Locality*:— N.S. 272, 2440 ft., 5 in. (Blackstone Formation).

*Remarks*:— The specific name refers to the provenance of the type material from the Blackstone Formation. This distinctive species is characterized by large, irregularly shaped, well separated, distal projections. The relative flatness, irregular shape and distinct separation of the projections are features of which assignment to *Pustulatisporites* has been based. In *Cycloverrutriletes* Schulz, 1964, the large distal projections are rounded and more regular in shape.

Previously described species of *Pustulatisporites* are all from Carboniferous strata. *P. blackstonensis* differs from the type species *P. pustulatus* Potonié & Kremp, 1954, in having much larger projections, relative to the overall size. *P. subornatus* Artüz, 1957 (1957, p. 245) has a subtriangular amb and more band-shaped sculptural elements. In *P. crenatus* Guennel 1958 (1958, p. 63) the projections are smaller and more conical than in the Queensland specimens. *P. gibberosus* (Hacquet) Playford, 1963, has projections which, although similar in size to those of *P. blackstonensis*, are more



isodiametric and relatively higher than in the Queensland species. *P. pretiosus* Playford, 1963, is much larger in overall size and exhibits considerable diversity in its sculptural elements.

*Distribution*:— Blackstone Formation, Aberdare Conglomerate (this paper).

Subinfraturma BACULATI Dybová and Jachowicz, 1957  
Genus BACULATISPORITES Thomson & Pflug, 1953

*Type Species*:— *Baculatisporites primarius* (Wolff) Thompson & Pflug, 1953.

*Baculatisporites comaumensis* (Cookson) Potonié, 1956  
Plate 2, Figure 6

*Figured specimen*:— Slide S2215, stage co-ordinates 11.4, 94.3; diameter 44 microns, Co-ordinates of lower right hand corner of cover glass 26.6, 84.4.

*Locality*:— N.S. 272, 2289 ft., 8 in. (Blackstone Formation).

*Distribution*:— Widespread in Australian Mesozoic sediments; has been reported in Europe from the upper Muschelkalk onwards (Klaus, 1960; Schulz, 1966). Queensland records: Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Cretaceous of Wallumbilla Formation (de Jersey and Paten, 1964); Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation (this paper).

Genus CADARGASPORITES de Jersey & Paten *emend.*  
Reiser & Williams, 1969

*Type species*:— *Cadargasporites baculatus* de Jersey & Paten *emend.* Reiser and Williams, 1969.

*Cadargasporites baculatus* de Jersey & Paten *emend.*  
Reiser & Williams, 1969

Plate 5, Figure 1

*Figured specimen*:— Slide S2137, stage co-ordinates 18.9, 94.6; equatorial diameter 58 microns. Co-ordinates of lower right hand corner of cover glass 27.8, 83.9.

*Locality*:— N.S. 272, 1332 ft., 10½ in. (Blackstone Formation).

*Remarks*:— This species has previously been recorded in Liassic assemblages from the Surat Basin (de Jersey & Paten, 1964, p. 5; Reiser and Williams, 1969, p. 5). Its presence in samples from the Blackstone and Raceview Formations indicates extension of its range into the Triassic.

*Distribution*:— Jurassic of Precipice Sandstone, Evergreen Formation, basal Hutton Sandstone of Surat Basin (de Jersey & Paten, 1964; Reiser & Williams, 1969); Triassic of Blackstone Formation, Raceview Formation (this paper).

*Cadargasporites granulatus* de Jersey & Paten *emend.*  
Reiser and Williams, 1969

*Remarks*:— One poorly preserved specimen of this species has been observed in the Raceview assemblages.

*Distribution*:— Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (de Jersey & Paten, 1964; Reiser and Williams, 1969); Triassic of Raceview Formation (this paper).

*Cadargasporites reticulatus* de Jersey & Paten, 1964

Plate 5, Figure 2

*Figured specimen*:— Slide S2146, stage co-ordinates 13.7, 92.9; equatorial diameter 73 microns, polar diameter 58 microns. Co-ordinates of lower right hand corner of cover glass 27.9, 83.1.

*Locality*:— N.S. 272, 1513 ft., 7 in. (Raceview Formation).

*Remarks*:— As in the case of *Cadargasporites baculatus*, recorded above, the discovery of *C. reticulatus* in assemblages from the Raceview Formation extends the range of this species back into the Triassic.

*Distribution*:— Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (de Jersey & Paten, 1964; Reiser and Williams, 1969); Triassic of Raceview Formation (this paper).

Genus NEORAISTRICKIA Potonié, 1956

*Type species*: *Neoraistrickia truncata* (Cookson)  
Potonié, 1956.

*Neoraistrickia taylorii* Playford & Dettmann, 1965

Plate 2, Figure 5

*Figured specimen*:— Slide S2210, stage co-ordinates 6.6, 86.2; diameter 38 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 84.5.

*Locality*:— N.S. 272, 2389 ft., 8 in. (Blackstone Formation).

*Distribution*:— Triassic and Jurassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Late Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Blackstone Formation, Raceview Formation (Hill, Playford and Woods, p. 65; this paper). Specimens recorded as *Neoraistrickia* sp. cf. *N. taylorii* have been observed in assemblages from the Clematis Sandstone (de Jersey, 1968).



Infraturma MURORNATI Potonié & Kremp, 1954  
 Genus DUPLEXISPORITES Deák *emend.* Playford & Dettmann, 1965

*Type species*:— *Duplexisporites generalis* Deák, 1962.

*Duplexisporites problematicus* (Couper) Playford & Dettmann, 1965

Plate 3, Figures 1, 2, 3

*Synonymy*:—

1958 *Cingulatisporites problematicus* Couper, p. 146, pl. 24, figs. 11-13

1965 *Duplexisporites problematicus* (Couper) Playford & Dettmann p. 140

1965 *Duplexisporites gyratus* Playford & Dettmann, pp. 141, 142; pl. 13, figs. 20-22

*Figured specimen* (Plate 3, Figure 1):— Slide S2162, stage co-ordinates 21.9, 88.8; diameter 46 microns. Co-ordinates of lower right hand corner of cover glass 28.1, 76.6.

*Locality*:— N.S. 272, 1600 ft., 2 in. (Raceview Formation).

*Figured specimen* (Plate 3, Figure 2):— Slide S2129, stage co-ordinates 7.0, 93.4; diameter 36 microns. Co-ordinates of lower right hand corner of cover glass 25.8, 82.4.

*Locality*:— N.S. 272, 1377 ft., 3 in. (Raceview Formation).

*Figured specimen* (Plate 3, Figure 3):— Slide S2166, stage co-ordinates 21.0, 96.1; diameter 45 microns. Co-ordinates of lower right hand corner of cover glass 26.3, 84.9.

*Locality*:— N.S. 272, 1600 ft., 2 in. (Raceview Formation).

*Remarks*:— On the basis of study of numerous specimens of *Duplexisporites* from the Triassic of the Sydney Basin, Mr. R. Helby (pers. comm.) regards *Duplexisporites gyratus* Playford & Dettmann, 1965, as a junior synonym of *D. problematicus* (Couper) Playford & Dettman, 1965. Study of specimens recorded in the present investigation supports this conclusion. Playford & Dettman (1965, p. 142) distinguished *D. gyratus* from *D. problematicus* because they considered that the latter species had more widely spaced muri with undulating crests. The additional material recorded in the present study indicates that there is considerable variation in *D. gyratus*; this variation extends to the features by which it was separated from *D. problematicus*. One of the specimens figured (Plate 3, Figure 2) shows close similarity to the holotype of *D. gyratus* (Playford and Dettmann, 1965, pl. 13, fig. 20); continuous gradation exists from such specimens to that figured in Plate 3, Figure 3 (with widely spaced muri) and to others such as that figured in Plate 3, Figure 1, in which the muri have undulating crests. Consequently no valid criteria are available by which *D. gyratus* can be distinguished from *D. problematicus*.

*Distribution*:— Middle Jurassic and Lower Cretaceous of Great Britain (Couper, 1958); Middle Keuper to Lower Cretaceous of East Germany (Schulz, Döring, 1966; Schulz, 1967); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Upper Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Mount Crosby Formation (Ipswich Coal Measures), Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965a, 1965b); Triassic of Wandoan Formation (de Jersey and Hamilton, 1969); Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964; Hill, Playford and Woods, 1965; this paper); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds, Queensland (Playford and Cornelius, 1967).

Genus FOVEOSPORITES Balmie, 1957

*Type species*:— *Foveosporites canalis* Balme, 1957.  
*Foveosporites moretonensis* de Jersey, 1964

Plate 3, Figure 4

*Figured specimen*:— Slide S2158, stage co-ordinates 12.3, 92.3; diameter 30 microns. Co-ordinates of lower right hand corner of cover glass 24.9, 81.9.

*Locality*:— N.S. 272, 1600 ft., 2 in. (Raceview Formation).

*Remarks*:— Specimens of this species are similar to those previously described (de Jersey, 1964, p. 7).

*Distribution*:— Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, this paper); Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (Reiser and Williams, 1969).

Genus LYCOPIDIUMSPORITES Thiergart ex Delcourt & Sprumont, 1955

*Type species*:— *Lycopodiumsporites agathoeus* (Potonié) Thiergart, 1938.

*Lycopodiumsporites rosewoodensis* (de Jersey) de Jersey, 1963

Plate 3, Figure 5

*Figured specimen*:— Slide S2129, co-ordinates 11.4, 88.9; diameter 35 microns. Co-ordinates of lower right hand corner of cover glass 25.8, 82.4.

*Locality*:— N.S. 272, 1377 ft., 3 in (Raceview Formation).

*Remarks*:— *Lycopodiumsporites rosewoodensis* is widely distributed in the Jurassic of Queensland. The discovery of the species, in assemblages from the Raceview Formation, extends its known range into the Late Triassic.

*Distribution*:— Jurassic of Walloon Coal Measures, Marburg Sandstone (de Jersey, 1959, 1963); Jurassic of Precipice Sandstone (de Jersey, 1959, 1963); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton



Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds, Queensland (Playford and Cornelius, 1967); Late Triassic of Raceview Formation (this paper).

Subturma ZONOTRILETES Waltz, 1935  
Infraturma TRICRASSATI Dettmann, 1963  
Genus CAMAROZONOSPORITES Pant ex Potonié  
emend. Klaus, 1960

*Type species*:— *Camarozonosporites cretaceus* (Weyland & Krieger) Potonié, 1956.

*Camarozonosporites rudis* (Leschik) Klaus, 1960

Plate 3, Figure 7

*Figured specimen*:— Slide S2168, stage co-ordinates 12.1, 96.7; diameter 35 microns. Co-ordinates of lower right hand corner of cover glass 28.0, 84.8.

*Locality*:— N.S. 272, 1634 ft., 10 in. (Aberdare Conglomerate).

*Remarks*:— The specimen figured conforms, in all essential diagnostic features, to the description of this species (Klaus, 1960, p. 136). It is the only specimen of the species observed in the present investigation.

*Distribution*:— Keuper of Switzerland (Leschik, 1955); Karnian, Norian, Rhaetian and Liassic of Austria (Klaus, 1960 and pers. comm.); Middle and Upper Keuper and Liassic of Germany (Mädler, 1964; Schulz, 1966, 1967); Upper Triassic of Canada (McGregor, 1965); Jurassic of Razorback Beds, Queensland (Playford and Cornelius, 1967); Precipice Sandstone, Evergreen Formation of Surat Basin (Reiser and Williams, 1969); Triassic of Aberdare Conglomerate (this paper).

Infraturma CINGULATI Potonié and Klaus, 1954  
Genus ANNULISPORIA de Jersey, 1959

*Type species*:— *Annulisporea folliculosa* (Rogalska) de Jersey, 1959.

*Annulisporea folliculosa* (Rogalska) de Jersey, 1959

*Remarks*: This species is a rare component of the Ipswich and Bundamba assemblages.

*Distribution*:— Liassic of Poland (Rogalska, 1954); Jurassic of Walloon Coal Measures, Marburg Sandstone (de Jersey, 1959, 1963); Precipice Sandstone, Evergreen Formation, Hutton Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964; Reiser & Williams, 1969); Jurassic of Razorback Beds, Queensland (Playford and Cornelius, 1967); Upper Triassic of Tasmania (Playford, 1965); Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1962, 1964, this paper).

*Annulisporea microannulata* de Jersey, 1962

Plate 3, Figure 6

*Figured specimen*:— Slide S2161, stage co-ordinates 13.9, 84.0; diameter 38 microns. Co-ordinates of lower right hand corner of cover glass 27.2, 79.4.

*Locality*:— N.S. 272, 1600 ft., 2 in. (Raceview Formation).

*Distribution*:— Triassic of Ipswich Coal Measures (de Jersey, 1962); Jurassic of Marburg Sandstone (de Jersey, 1963); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964); (Reiser and Williams, 1969); Jurassic of Razorback Beds, Queensland (Playford and Cornelius, 1967); Triassic of Blackstone Formation, Bundamba Group (de Jersey, 1964, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b).

Genus DENSOSPORITES (Berry) Butterworth, Jansonius, Smith and Staplin, 1964

*Type species*:— *Densosporites covensis* Berry, 1937 cf. *Densosporites* sp.

Plate 3, Figure 9

*Description*:— Amb circular or subcircular. Diameter (4 specimens) 30 to 33 microns. Trilete; laesurae, straight or slightly sinuous, with slight development of lips, extend to, or almost to equator. Dense cingulum, width in polar view about 5 to 7 microns, tapering towards equator. Exine smooth or faintly punctate.

*Figured specimen*:— Slide S2145, stage co-ordinates 21.1, 96.1; diameter 31 microns. Co-ordinates of lower right hand corner of cover glass 25.1, 82.8.

*Locality*:— N.S. 272, 1513 ft., 7 in. (Raceview Formation).

*Remarks*:— Butterworth *et al.* (1964, p. 1052) specified the presence of an inner layer in their emended diagnosis of *Densosporites*. Consequently, in the absence of evidence for the presence of an intexine in these specimens, conclusive assignment to the genus is not possible.

*Distribution*: Raceview Formation (this paper).

Genus DISTALANULISPORITES Klaus, 1960

*Type species*:— *Distalanulisporites punctus* Klaus, 1960

*Remarks*:— Although Potonié (1966, p. 52, 54) believed that this genus should be identified with *Annulisporea* de Jersey, 1959, it is considered that evidence for uniting the genera is not yet entirely conclusive. Criteria which may serve to differentiate the genera have been indicated previously (de Jersey, 1962, p. 5). Of these, the presence of curvaturae in *Distalanulisporites* appears to be the most significant; these have not been observed by the writer in any specimens of *Annulisporea*, a genus in which the laesurae do not extend to the equator, nor to the inner boundary of the cingulum.

*Distalanulisporites* sp. cf. *D. punctus* Klaus, 1960

Plate 3, Figure 8

*Figured specimen*:— Slide S2229, stage co-ordinates 19.7, 86.1; diameter 33 microns. Co-ordinates of lower right hand corner of cover glass 28.2, 85.0.



*Locality*:— N.S. 272, 2045 ft., 10 in. (Blackstone Formation).

*Remarks*:— The specimen figured exhibits distinct curvaturae at the ends of the laesurae, a characteristic feature of *Distalanulisporites punctus* (Klaus, 1960, p. 133). As stated previously (de Jersey, 1962, p. 5) this is a feature by which *D. punctus* can be distinguished from *Annulispora folliculosa* (Rogalska) de Jersey. In the latter species the laesurae extend only one-half to three-quarters of the amb radius, and curvaturae have not been observed in any of the numerous specimens examined from the Triassic and Jurassic of Queensland. Another feature which may assist in distinguishing these species is the darkening of the distal polar region (within the circumpolar ridge) evident in the specimen figured (Plate 3, Figure 8). In *A. folliculosa* the exine is of uniform thickness within and outside this ridge.

The only difference of possible significance between this specimen and the holotype of *D. punctus*, figured by Klaus (1960, pl. 28, fig. 8) is that the latter has a faintly punctate exine. As this is the only specimen of this type observed in the Queensland assemblage, it has not been possible to explore variation in this feature; consequently it is compared, rather than identified, with *D. punctus*.

*Distribution*:— Blackstone Formation (this paper).

*Distribution of Distalanulisporites punctus*:— Karanian of Austria (Klaus, 1960); Rhaetian and Liassic of East Germany (Schulz, 1966).

Genus POLYINGULATISPORITES Simoncsics & Kedves, 1961 *emend.* Playford & Dettmann, 1965

*Type species*:— *Polycingulatisporites circulus* Simoncsics & Kedves, 1961.

*Polycingulatisporites crenulatus* Playford & Dettmann, 1965

Plate 3, Figures 10, 11, 12; Plate 4, Figure 1

*Synonym*:—

1967 *Neochomotriletes triangularis* (Bolkhovitina) Reinhardt, 1962; in Schulz, 1967, p. 587, pl. 14, Figs. 10, 11.

*Figured specimen (Plate 3, Figure 10)*:— Slide S2129, stage co-ordinates 11.2, 82.6; diameter 41 microns. Co-ordinates of lower right hand corner of cover glass 25.8, 82.4.

*Locality*:— N.S. 272, 1377 ft., 3 in. (Raceview Formation).

*Figured specimen (Plate 3, figure 11)*:— Slide S2177, stage co-ordinates 17.8, 93.2; diameter 50 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 83.7.

*Locality*:— N.S. 272, 1634 ft., 10 in. (Aberdare Conglomerate).

*Figured specimen (Plate 3, Figure 12)*:— Slide S2174, stage co-ordinates 21.3, 103.4; diameter 36 microns. Co-ordinates of lower right hand corner of cover glass 26.8, 84.7.

*Locality*:— N.S. 272, 1634 ft., 10 in. (Aberdare Conglomerate).

*Figured specimen (Plate 4, Figure 1)*:— Slide S2138, stage co-ordinates 20.6, 95.4; diameter 43 microns. Co-ordinates of lower right hand corner of cover glass 27.6, 81.5.

*Locality*:— N.S. 272, 1332 ft., 10½ in. (Raceview Formation).

*Remarks*:— This species was described, initially, on the basis of material from the Leigh Creek Coal Measures of South Australia (Playford and Dettmann, 1965, pp. 145, 146). Study of additional specimens from the Jurassic of Queensland (de Jersey and Paten, 1964; Playford and Cornelius, 1967, Reiser & Williams, 1969) and from the Upper Triassic of the Bundamba Group (this paper) has shown that the species exhibits a somewhat broader range of variation than that recorded in the original diagnosis. The evidence for a wider range of variation can be summarized, with regard to four features, which are: (1) overall size, (2) shape of the amb, (3) diameter of the subpolar ridge and (4) distinctness of radial striations on the cingulum and distal ridges.

Concerning the first of these features, some broadening of the size range can be expected from the study of additional material. The range in equatorial diameter initially recorded by Playford and Dettmann (1965, p. 146) was from 43 to 59 microns. This was extended slightly by de Jersey and Paten (1964, pl. 7) who quoted a size range of 41 to 66 microns for specimens from the Surat Basin. Four specimens figured by Playford and Cornelius (1967, pl. 2, figs. 1-4) range from 35 to 44 microns, thus extending the lower limit of the size range. This extension of the size range is supported by measurements of specimens recorded from the Aberdare Conglomerate and Raceview Formation, for which the equatorial diameter (based on 13 measured specimens) ranges from 36 to 50 microns.

Continuous variation is also evident in the shape of the amb, originally described by Playford and Dettmann (1965, p. 145) as convexly subtriangular. Study of additional material, recorded in the papers cited, has shown that there is continuous gradation, in equatorial outline, from subtriangular to subcircular.

As in the case of the overall equatorial diameter, measurements of the diameter of the subpolar ridge indicate an extension of the lower limit of the size range on the basis on additional material. Thus de Jersey and Paten (1964, p. 7) recorded a range of 10 to 16 microns in the external diameter of the subpolar ridge as compared with 20 to 24 microns in the three specimens figured by Playford and Dettmann (1965). In specimens figured by Playford and Cornelius (1967) the subpolar ridge ranges from 9 to 13 microns in external diameter; the range is from 7 to 16 microns for specimens recorded in the present study. The evidence from these more recent investigations favours the view that there is continuous variation in the subpolar ridge from specimens such as that figured in Plate 4, Figure 1 (which in this feature is close to the specimens originally



figured by Playford and Dettmann) to specimens with smaller subpolar ridges, such as those figured in Plate 3, Figures 10, 11 and 12.

Finally, the distinctness of the radial striations on the cingulum and distal ridges is also a variable feature. In the Bundamba specimens, recorded here, there is continuous gradation from specimens with distinct radial striations (Plate 3, Figures 11, 12) through specimens with faintly marked striations, to those in which the ridges appear completely smooth (Plate 4, Figure 1). Similar variation is evident in specimens recorded from the Jurassic of Queensland. The distinctions of the radial striations may even vary within one specimen (e.g. that illustrated in Plate 3, Figure 12). Apart from the possibility of original variation in the species, variation in the distinctness of the striations may also be related to variation in preservation or laboratory processing. Accordingly, in view of the continuous variation in this feature, the presence of distinct radial striations on the cingulum and distal ridges is not now regarded as an essential diagnostic requirement for this species.

In accordance with present knowledge of the circumscription of the species, taking into account variation in the above features, the Middle Rhaetic specimen figured by Schulz (1967, pl. 14, figs. 10, 11) is placed in synonymy with *P. crenulatus*. It is indistinguishable, in significant diagnostic features, from Queensland specimens assigned to this species.

The writer is in agreement with Playford and Dettmann (1965, p. 146) in maintaining *Polycingulatisporites crenulatus* as a species, distinct from *P. triangularis* (Bolkhovitina) Playford and Dettmann. As mentioned by those authors, the Russian species appears to differ in having narrower, more widely spaced distal thickenings. Detailed comparison is not possible on the basis of the brief description of the Russian spores; in particular, it is not clear whether the distal polar thickening in the latter is invariably a solid circular structure, rather than an annular ridge as in *P. crenulatus*.

Similar specimens have been recorded from the Rhaetian of Thüringia by Reinhardt (1962, pl. 1, figs. 1, 5) as *Neochomotrilites triangularis* (Bolkhovitina) Reinhardt. They resemble *P. triangularis* in having narrow, widely spaced distal thickenings. The nature of the distal polar thickening is not clear from Reinhardt's figures. For this reason the relationship to *P. crenulatus* cannot be fully assessed and consequently these specimens are also regarded, provisionally, as distinct from the latter, until further information is available.

**Distribution:**— Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic Razorback Beds, Queensland (Playford and Cornelius, 1967); Middle Rhaetian of East Germany (Schulz, 1967); Triassic of Aberdare Conglomerate, Raceview Formation (this paper).

*Polycingulatisporites densatus* (de Jersey) Playford & Dettmann, 1965

Plate-4, Figure 2

**Figured Specimen:**— Slide S2210, stage co-ordinates 17.6, 88.0; diameter 25 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 84.5.

**Locality:**— N.S. 272, 2389 ft., 8 in. (Blackstone Formation).

**Distribution:**— Jurassic of Walloon Coal Measures, Rosewood Coalfield (de Jersey, 1959); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Jurassic of Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Razorback Beds, Queensland (Playford and Cornelius, 1967); Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation (de Jersey, 1964, this paper); Triassic of Mount Crosby Formation (de Jersey and Hamilton, 1965a).

*Polycingulatisporites mooniensis* de Jersey & Paten, 1964

Plate 4, Figure 3

**Figured specimen:**— Slide S2149, stage co-ordinates 9.6, 101.1; diameter 33 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 82.3.

**Locality:**— N.S. 272, 1513 ft., 7 in. (Raceview Formation).

**Remarks:**— Only two specimens of this species have been observed in the assemblages studied. It differs from *Polycingulatisporites crenulatus*, recorded above, in being somewhat smaller and in lacking the prominent thickened lips of that species.

**Distribution:**— Jurassic of Precipice Sandstone and lower Evergreen Formation, Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds, Queensland (Playford and Cornelius, 1967); Triassic of Raceview Formation (this paper).

Subturma PERINOTRILITES Erdtman, 1947  
Genus SEMIRETISPORIS Reinhardt, 1962

**Type species:**— *Semiretisporis gothae* Reinhardt, 1962.

**Remarks:**— Characteristic features of this genus are its murornate distal sculpture, forming a reticulum, flange-like equatorial zone with radiating ridges, and the presence of an intexine. It is here interpreted broadly, to include both species with a perfect distal reticulum, such as *S. gothae* and species with an imperfect reticulum (formed by distal rugulae or foveolae) such as *S. antiquus* (de Jersey) comb. nov. and *S. denmeadi* (de Jersey) comb. nov.

As pointed out by Schulz (1967, p. 578) *Limbo-sporites* Nilsson 1958 is very similar, in having distal foveolae which, when closely spaced, constitute a reticulum. Potonié (1960, p. 47) has demonstrated that this generic name is invalid since, being monotypic, it was not accompanied by a description or diagnosis



of the genus (see Article 42, International Code of Botanical Nomenclature, 1966). Accordingly it seems likely that the species *Limbosporites lundbladii* should be transferred to the later, but valid genus *Semiretisporis* Reinhardt, 1962.

*Semiretisporis antiquus* (de Jersey) comb. nov.

Plate 4, Figures 4, 5, 6, 7

*Synonym*:—

1964 *Lycopodiumsporites antiquus* de Jersey, 1964, p. 5, pl. 1, fig. 5.

*Description*:— Trilete miospores. Diameter (based on 30 measured specimens) 31 to 53 microns. Laesurae straight, length about three-quarters spore radius, may have slight development of lips. Exine two-layered, consisting of a thin, smooth, homogenous inner layer proximally attached to a sculptured exoexine. Proximal exoexine smooth, distal exoexine with foveolate sculpture. Foveolate in central distal region subcircular to oval, 1.5 to 5 microns in diameter, variable in size within each specimen, may form a reticulum. Equatorial foveolae about 3 to 5 microns in diameter (tend to be larger than distal foveolae), separated by low, radially arranged muri which are about 1.5 to 2.5 microns in width. Exoexine (apart from distal sculpture) about 1 to 2 microns in thickness.

*Figured specimen* (Plate 4, Figure 4):— Slide S2126, stage co-ordinates 20.1, 87.6; diameter 46 microns. Co-ordinates of lower right hand corner of cover glass 26.0, 82.1.

*Locality*:— N.S. 272, 1377 ft., 3 in. (Raceview Formation).

*Figured specimen* (Plate 4, Figure 5):— Slide S2126, stage co-ordinates 18.2, 93.1; diameter 40 microns. Co-ordinates of lower right hand corner of cover glass 26.0, 82.1.

*Locality*:— N.S. 272, 1377 ft., 3 in. (Raceview Formation).

*Figured specimen* (Plate 4, Figure 6):— Slide S2173, stage co-ordinates 16.3, 96.9; diameter 41 microns. Co-ordinates of lower right hand corner of cover glass 26.8, 84.0.

*Locality*:— N.S. 272, 1634 ft., 10 in. (Aberdare Conglomerate).

*Figured specimen* (Plate 4, Figure 7):— Slide S2145, stage co-ordinates 21.0, 93.0; diameter 48 microns. Co-ordinates of lower right hand corner of cover glass 25.1, 82.8.

*Locality*:— N.S. 272, 1513 ft., 7 in. (Raceview Formation).

*Remarks*:— Study of additional specimens has provided further data on the range of variation in this species. The specimens figured (Plate 4, Figures 4-7) form a series illustrating the principal type of variation (in the spacing of the distal foveolae). These are closely spaced, constituting a reticulum, in the specimen figured in Plate 4, Figure 6; this specimen shows close similarity

to the holotype (de Jersey, 1964, pl. 1, fig. 5). Intermediate specimens, with more widely spaced foveolae, are illustrated in Plate 4, Figures 5 and 6. An extreme case, in which the foveolae are so widely spaced that all semblance of a reticulum is lost, is illustrated by the specimen figured in Plate 4, Figure 4.

The species is here transferred to *Semiretisporis* Reinhardt as a new combination. This is because it exhibits the significant diagnostic features of the genus, including the characteristic differentiation of sculpture into relatively smaller distal and relatively larger equatorial foveolae or lumina. In *Lycopodiumsporites* the lumina show no such differentiation in size between distal and equatorial regions.

Specimens with widely spaced foveolae, as illustrated in Plate 4, Figure 4, show close similarity to the holotype of *Limbosporites lundbladii* Nilsson, described by Nilsson (1958, pl. 3, fig. 7) from the Liassic of Sweden. From this similarity, it seems possible that the species may eventually be united. However further information on the range of variation of the European species is desirable before it is regarded as synonymous with *S. antiquus*. In particular, specimens from the Rhaetic of East Germany, assigned by Schulz (1967, p. 576, pl. 9, figs 12-16, pl. 24, fig. 2) to *L. lundbladii* show differentiation in the distal sculpture into larger and smaller foveolae; such differentiation has not been observed to a similar extent in Queensland specimens of *S. antiquus*.

Spores of the *Limbosporites lundbladii* type appear to be widely distributed in the Rhaetic and Liassic of Europe; apart from the records of Nilsson (1958) and Schulz (1966, 1967), the Rhaetic species *Dentellisporites achimensis* Mädlar is also regarded by Schulz (1967, p. 571) as synonymous with this species.

*Distribution of S. antiquus*:— Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, this paper); Triassic of Moorooka Formation, Brisbane area (de Jersey and Hamilton, 1965b).

*Semiretisporis denmeadi* (de Jersey, 1962) comb. nov.

Plate 4, Figure 8

*Synonymy*:—

1953 Type 34B of Taylor, pp. 161, 162

1962 *Callialasporites denmeadi* de Jersey, p. 14, pl. 6, figs. 2, 3

1965 *Lundbladispore denmeadi* (de Jersey) Playford & Dettmann, pp. 148, 149, pl. 15, figs. 36 a-c.

1965 *Lundbladispore denmeadi* (de Jersey) Playford & Dettmann. in Playford, 1965, p. 190, pl. 9, figs. 3-5

*Description*:— Trilete miospores. Amb convexly subtriangular to subcircular. Equatorial diameter 48 to 92 microns; diameter of intexine 25 to 74 microns. Laesurae distinct to imperceptible, where evident straight, length about half to three-quarters spore radius, with slight development of lips. Exine two-layered, consisting of an inner homogeneous layer that, apart from proximal attachment, is separated from a



structured exoexine. Exoexine consisting of an inner region and an equatorial region, which is 5 to 12 microns in width, with radially developed ridges, about 1.5 microns in width, that bifurcate towards the equator. Inner region of distal exoexine with murornate sculpture, consisting of low, irregular rugulae about 1.5 to 3 microns wide, forming a reticulum imperfectum with lumina from 2 to 10 microns. Distal rugulae anastomosing or freely terminating. Inner layer smooth, thin (less than 1 micron), in well preserved specimens exhibits 3 low, proximally situated, interrational polar thickenings (papillae).

*Figured specimen*:— Slide S2209, stage co-ordinates 19.6, 90.6; diameter 61 microns. Co-ordinates of lower right hand corner of cover glass 25.6, 82.4.

*Locality*:— N.S. 272, 2389 ft., 8 in.

*Remarks*:— The above description is based on all recorded specimens of the species, including the original type material (de Jersey, 1962, p. 14), the well preserved material from the Leigh Creek Coal Measures (Playford and Dettman, 1965, p. 148) and specimens from the Blackstone Formation observed in the present study. Certain features, such as the inner layer of exine and the laesurae are detected only in well preserved spores of this species; they are difficult to recognize in poorly preserved specimens, presumably because of the thinness of the proximal exoexine, and of the intexine.

Concerning the taxonomic history of the species, it was originally assigned to *Callialasporites* (de Jersey, 1962, p. 14) because its trilete character was not clearly shown in the type material, from the Tivoli Formation of the Ipswich Coal Measures. Playford and Dettmann (1965, p. 148) from an examination of well preserved specimens from the Leigh Creek Coal Measures, demonstrated the presence of trilete laesurae and of an inner layer and accordingly transferred the species to *Lundbladispota* Balme, 1963. However the diagnosis of the latter, as emended by Playford (1965, p. 189) specifies the presence of a "narrow equatorial thickening (cingulum)" and distal sculpture of the exoexine "consisting of small coni, spinae or grana". Assignment of the species to *Lundbladispota*, as defined by Playford's diagnosis, is thus inappropriate as the equatorial region of the exoexine is relatively broad and flange-like rather than a narrow cingulum and also because the distal sculpture is murornate, rather than apiculate (consisting of irregular rugulae, not coni, spinae or grana). Accordingly the species is here assigned to *Semiretisporis* Reinhardt, 1962, as a new combination. This genus, as indicated above, is characterized by features which include murornate distal sculpture, a flange-like equatorial region and an inner layer (intexine) — all features possessed by *S. denmeadi* (de Jersey) comb. nov.

The murornate distal sculpture of this species is illustrated by the specimen figured (Plate 4, Figure 8). This specimen, from the basal part of the Blackstone Formation, exhibits well preserved, distal rugulae. *S. denmeadi* differs from other species of the genus in having an imperfect, rather than a perfect, distal

reticulum. In overall size it is comparable with the type species, *S. gothae* Reinhardt, 1962, but that species differs both in having a perfect distal reticulum with relatively large lumina and a broader equatorial flange.

*Distribution*:— Triassic of Tivoli and Blackstone Formations of Ipswich Coal Measures (de Jersey, 1962; Hill, Playford and Woods, 1965; this paper); Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b).

|            |                                                                |
|------------|----------------------------------------------------------------|
| Turma      | MONOLETES Ibrahim, 1933                                        |
| Subturma   | AZONOMONOLETES Luber, 1935                                     |
| Infraturma | SCULPTATOMONOLETI Dybová & Jachowicz, 1957                     |
| Genus      | ARATRISPORITES Leschik <i>emend.</i> Playford & Dettmann, 1965 |

*Type species*:— *Aratrisporites parvispinosus* Leschik *emend.* Playford, 1965.

*Aratrisporites banksi* Playford, 1965

Plate 5, Figure 4

*Figured specimen*:— Slide S2232, stage co-ordinates 11.9, 91.0; dimensions 96 x 63 microns, inner layer 63 x 35 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 84.0.

*Locality*:— N.S. 272, 2045 ft., 10 in. (Blackstone Formation).

*Remarks*:— Two specimens, assigned to this species, have been recorded in the present study.

*Distribution*:— Triassic of Tiers Formation, Tasmania (Playford, 1965); Triassic of Blackstone Formation (Hill, Playford and Woods, 1965; this paper).

*Aratrisporites flexibilis* Playford and Dettmann, 1965

Plate 5, Figure 3

*Figured specimen*:— Slide S2218, stage co-ordinates 16.1, 95.1; dimensions 66 x 40 microns. Co-ordinates of lower right hand corner of cover glass 27.1, 84.0.

*Locality*:— N.S. 272, 2289 ft., 8 in. (Blackstone Formation).

*Remarks*:— Three specimens have been recorded, of which the specimen figured (Plate 5, Figure 3) is representative. They have the typical features of the species, described by Playford and Dettmann (1965, pp. 153, 154). The nature and sparse distribution of the sculptural elements are particularly characteristic. (The latter feature differentiates this species from the more densely spinose *A. tenuispinosus* Playford, 1965).

*Distribution*:— Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Blackstone Formation (Hill, Playford and Woods, 1965; this paper).



*Aratrisporites parvispinosus* Leschik *emend.* Playford, 1965

*Distribution*:— Middle Keuper of Switzerland (Leschik, 1965); Upper Triassic of Tasmania (Playford, 1965); Triassic of Blackstone Formation (Hill, Playford and Woods, 1965).

Genus POLYPODIISPORITES Potonié & Gelletich *ex* Potonié, 1956

*Type species*:— *Polypodiisporites favus* (Potonié) Potonié & Gelletich, 1933.

*Polypodiisporites ipsviciensis* (de Jersey) Playford & Dettmann, 1965

*Distribution*:— Triassic of Ipswich Coal Measures (de Jersey, 1962, this paper); Upper Triassic of Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, this paper); Triassic of Moorooka and Tingalpa Formations, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Ross Formation, Tasmania (Playford, 1965); Triassic of Wollar Sandstone, New South Wales (Helby, 1967); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970).

Genus PUNCTATOSPORITES Ibrahim, 1933

*Type species*:— *Punctatosporites minutus* Ibrahim, 1933.

*Punctatosporites walkomi* de Jersey, 1962

*Distribution*:— Triassic of Ipswich Coal Measures (de Jersey, 1962, this paper); Upper Triassic of Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, this paper); Triassic of Moorooka and Tingalpa Formations, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (Reiser and Williams, 1969).

Genus TUBERCULATOSPORITES Imgrund, 1952

*Type species*:— *Tuberculatosporites anicystoides* Imgrund, 1952.

*Tuberculatosporites aberdarensis* de Jersey, 1964

*Distribution*:— Triassic of Aberdare Conglomerate, Ripley Road Sandstone (de Jersey, 1964); Triassic of Blackstone Formation (this paper). Specimens recorded as *Tuberculatosporites* sp. cf. *T. aberdarensis* have been observed in assemblages from the Moolayember Formation (de Jersey and Hamilton, 1967).

|               |                                                           |
|---------------|-----------------------------------------------------------|
| Anteturma     | POLLENITES Potonié, 1931                                  |
| Turma         | SACCITES Erdtman, 1947                                    |
| Subturma      | MONOSACCITES Chitaley <i>emend.</i> Potonié & Kremp, 1954 |
| Infraturma    | TRILETESACCITI Leschik, 1955                              |
| Subinfraturma | INTRORNATI Butterworth & Williams, 1958                   |
| Genus         | GUTHOERLISPORITES Bharadwaj, 1954                         |

*Type species*:— *Guthoerlisporites magnificus* Bharadwaj, 1954.

*Guthoerlisporites cancellosus* Playford and Dettmann, 1965

*Remarks*:— *Guthoerlisporites cancellosus* is a rare component of some of the assemblages recorded in the present study. It is evidently long-ranged, within the Australian Triassic.

*Distribution*:— Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1969); Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation (Hill Playford and Woods, 1965; this paper).

Subturma DISACCITES Cookson, 1947

*Remarks*:— Bisaccate pollen grains are abundant, or even dominant, in most of the assemblages which form the basis of the present investigation. In an earlier paper (de Jersey, 1962, pp. 7-9) the similarity of many of these specimens to pollen grains of the microsporophyll *Pteruchus* was emphasised and three specific types, recorded as *Alisporites australis* de Jersey, 1962, *Alisporites* sp. 1 and *Alisporites* sp. 2, were distinguished. Later studies on Triassic microfloras have shown, however, that because of poor preservation, unfavourable presentation and the inherent variability of these grains, specific differentiation is a difficult task. Furthermore it seems likely that any specific grouping of these pollen grains would have little stratigraphic application, within the Triassic. Accordingly in the present study bisaccate grains, apart from the species recorded below, which are probably distinct from *Pteruchus* are recorded simply as "Disaccites spp., (indet)."

Difficulty is experienced, even at the generic level, in classification of these grains. The species *Alisporites australis* (de Jersey, 1962, pp. 8, 9) exhibits a distinct colpus (or sulcus) in well preserved, suitably oriented specimens. Since this species was described, Klaus (1963, p. 332) has re-defined the genus *Falcisporites*, listing the presence of a distinct sulcus as a feature in his emended diagnosis. Thus colpate grains of *A. australis* could be assigned to *Falcisporites* Leschik *emend.* Klaus, 1963. However in the Ipswich-Bundamba assemblages only a small portion of the grains exhibit distinct colpi; the majority, although all their other features would indicate affinity with *Pteruchus*, lack a definite colpus (perhaps because of poor preservation) and so should be excluded from *Falcisporites* and assigned to *Alisporites*. This practical difficulty



of generic classification of such dispersed grains has been avoided in the present study by recording them as "Disaccites spp. (indet)" in the assemblage lists. Other bisaccate grains, assigned to different distinctive species, are recorded separately below and in the assemblage lists and microfloral distribution chart.

Genus ALISPORITES Daugherty, 1941

*Type species*:— *Alisporites opii* Daugherty, 1941.

*Alisporites lowoodensis* de Jersey, 1963

*Remarks*:— One specimen of *Alisporites lowoodensis* has been observed, in an assemblage from the Raceview Formation. This record extends the known range of the species into the Late Triassic.

*Distribution*:— Jurassic of Marburg Sandstone (de Jersey, 1963); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds, Queensland (Playford and Cornelius, 1967); Late Triassic of Raceview Formation (this paper).

Genus CHORDASPORITES Klaus, 1960

*Type species*:— *Chordasporites singulichorda* Klaus, 1960.

*Chordasporites australiensis* Klaus, 1960

Plate 6, Figure 1

*Figured specimen*:— Slide S2229, stage co-ordinates 24.6, 89.7; total span 91 microns. Co-ordinates of lower right hand corner of cover glass 28.2, 85.0.

*Locality*:— N.S. 272, 2045 ft., 10 ins. (Blackstone Formation).

*Distribution*:— Triassic of Ipswich Coal Measures (de Jersey, 1962, this paper); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968).

Genus INDUSIISPORITES Leschik, 1955

*Type species*:— *Indusiisporites velatus* Leschik, 1955.  
*Indusiisporites* sp.

*Remarks*:— A few specimens, assigned to this genus, have been observed. Their preservation is too poor for specific identification.

*Distribution*:— Blackstone Formation, Raceview Formation (this paper).

Genus PLATYSACCUS Naumova ex Potonié & Klaus, 1954

*Type species*:— *Platysaccus papilionis* Potonié & Klaus, 1954.

*Platysaccus queenslandi* de Jersey, 1962

*Distribution*:— Triassic of Ipswich Coal Measures (de Jersey, 1962, this paper); Upper Triassic of Bun-

damba Group (de Jersey, 1964, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965); Triassic and Jurassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970).

Genus SULCOSACCISPORA Klaus, 1964

*Type species*:— *Sulcosaccispora minuta* Klaus, 1964.  
*Sulcosaccispora alaticonformis* (Malyavkina) de Jersey, 1968

Plate 6, Figure 2

*Figured specimen*:— Slide S2162, stage co-ordinates 22.3, 81.6; dimensions 43 x 43 microns. Co-ordinates of lower right hand corner of cover glass 28.1, 76.6.

*Locality*:— N.S. 272, 1600 ft., 2 in. (Raceview Formation).

*Distribution*:— Lower and Middle Triassic of U.S.S.R. (Malyavkina, 1964); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Upper Rewan Formation (de Jersey, 1968, 1969); Triassic of Blackstone Formation (this paper).

Genus VITREISPORITES Leschik *emend.* Jansonius, 1962

*Type species*:— *Vitreisporites signatus* Leschik, 1955.  
*Vitreisporites microsaccus* de Jersey, 1964

*Distribution*:— Triassic of Blackstone Formation, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, this paper).

*Vitreisporites pallidus* (Reissinger) Nilsson, 1958

*Distribution*:— Widespread in Mesozoic sediments. Queensland records: Jurassic of Walloon Coal Measures, Marburg Sandstone (de Jersey, 1959, 1963); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds, Queensland (Playford and Cornelius, 1967); Cretaceous of Eromanga Basin (Haskell, 1968); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970); Triassic of Blackstone Formation Raceview Formation (this paper).

Subturma STRIATITES Pant, 1954

Genus HAMIAPOLLENITES Wilson, 1962

*Type species*:— *Hamiapollenites saccatus* Wilson, 1962  
*Hamiapollenites insculptus* Playford & Dettmann, 1965

*Remarks*:— One poorly preserved specimen of this species (in an assemblage from the Raceview Formation) has been observed in the course of the present study.



*Distribution*:— Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Blackstone Formation, Ipswich Coal Measures (Hill, Playford and Woods, 1965); Middle Triassic of lower Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970); Upper Triassic of Raceview Formation (this paper).

Turma ALETES Ibrahim, 1933  
 Subturma AZONALETES Lubert *emend.* Potonié & Kremp, 1954  
 Infraturma PSILONAPITI Erdtman, 1947  
 Genus INAPERTUROPOLLENITES (Pflug) *ex* Thomson & Pflug *emend.* Potonié, 1966

*Type species*:— *Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug, 1953.

*Inaperturopollenites* spp.

*Remarks*:— The writer has previously assigned grains from the Ipswich Coal Measures and Bundamba Group (de Jersey, 1962, p. 13; 1964, p. 11) to the species *Inaperturopollenites reidi* de Jersey, 1959 (originally described from the Jurassic of the Walloon Coal Measures — de Jersey, 1959, p. 362). In the present study, specific differentiation of these inaperturate grains has not been attempted, thereby avoiding difficulties inherent in comparing them with European species. Specimens of *Inaperturopollenites* are widely distributed in the Lower Mesozoic of Queensland; they appear to have negligible stratigraphic significance, within the Triassic sequence. Within the succession investigated, grains of this type have been recorded in assemblages from the Blackstone Formation, Aberdare Conglomerate and Raceview Formation.

Genus PILASPORITES Balme & Hennelly, 1956

*Type species*:— *Pilasporites calculus* Balme & Hennelly 1956.

*Pilasporites fuscus* de Jersey, 1962

*Remarks*:— The writer has followed Potonié (1960, p. 84) in maintaining *Pilasporites* as a genus, distinct from *Inaperturopollenites*, on the basis of the thinner, more readily folded exine of the latter.

*Distribution*:— Triassic of Ipswich Coal Measures (de Jersey, 1962), Aberdare Conglomerate (this paper).

Infraturma GRANULONAPITI Cookson, 1947  
 Genus ARAUCARIACITES Cookson *ex* Couper, 1953

*Type species*:— *Araucariacites australis* Cookson, 1947.  
*Araucariacites* sp.

*Remarks*:— Specimens recorded as *Araucariacites* differ from those assigned to *Conaletes* in having granulate, not conate, sculptural elements. They occur sporadically in the assemblages studied.

*Distribution*:— Blackstone Formation, Aberdare Conglomerate, Raceview Formation (this paper).

Genus CONALETES Reinhardt & Schön, 1967

*Type species*:— *Conaletes apiculatus* Reinhardt & Schön, 1967.

*Conaletes* sp.

Plate 3, Figure 5

*Description*:— Alete, outline subcircular, frequently distorted by folding. Diameter (based on 24 measured specimens) 33 to 66 microns. Exine with dense comprehensive sculpture of coni and grana; basal diameter and height of sculptural elements each ranging from 0.5 to 1.5 microns, about 1 micron apart. Exine thin (about 0.5 to 1 micron), with secondary folding.

*Figured specimen*:— Slide S2158, stage co-ordinates 17.0, 88.7; diameter 40 microns. Co-ordinates of lower right hand corner of cover glass 24.9, 81.9.

*Locality*:— N.S. 272, 1600 ft., 2 in. (Raceview Formation).

*Remarks*:— The specimen figured is representative of alete grains with the distinctive sculpture of this genus. Reinhardt and Schön (1967, pp. 752, 753) have distinguished species of *Conaletes* on the basis of overall size and the size of the sculptural elements. It has been found difficult to apply these criteria to these Queensland specimens, either in relating them to the described species or in subdividing the specimens on which the above description has been based. The former criterion (overall size) is difficult to apply with any precision to these thin, readily folded grains, the dimensions of which are significantly affected by the presence of secondary folds. From the latter aspect, the Queensland specimens show apparently continuous gradation in the size of the sculptured elements, so that this feature is also difficult to apply in any closer grouping. Accordingly more precise taxonomic treatment of this rather variable group of specimens must await study of more, and better preserved material.

*Distribution*:— Blackstone Formation, Aberdare Conglomerate, Raceview Formation (this paper).

Infraturma CIRCUMPOLLINI Pflug *emend.* Klaus, 1960  
 Genus DISCISPORITES Leschik *emend.* de Jersey, 1964

*Type species*:— *Discisporites niger* Leschik, 1955.

*Discisporites psilatus* de Jersey, 1964

*Remarks*:— Specimens from the Middle Triassic of the Moolayember Formation (de Jersey and Hamilton, 1967, p. 19) and from the Lower Triassic of the Rewan Formation (de Jersey, 1970, p. 20) have been assigned to this species, originally described from the Bundamba Group (de Jersey, 1964, p. 12). In a recent study of miospores from the Triassic of the Sydney Basin, Mr. R. Helby (pers. comm.) has placed in the genus *Polycingulatisporites* specimens which are approximately coeval with specimens assigned to this species,



from the Rewan and Moolayember Formations. The specimens from the latter formations are of similar morphology and specifically identifiable with those from the Sydney Basin. Mr. Helby's abundant and well preserved material shows clearly that *Polycingulatisporites* is the most appropriate genus in which to place these specimens, and that they can be distinguished from *Discisporites psilatus* de Jersey, 1964. Accordingly the specimens from the Rewan and Moolayember Formations are now excluded from *D. psilatus*.

*Distribution*:— Triassic of Raceview Formation, Ripley Road Sandstone, (de Jersey, 1964, this paper).

Genus *DUPLICISPORITES* Leschik, *emend.* Klaus, 1960  
*Type species*:— *Duplicisporites granulatus* Leschik, 1955.

*Duplicisporites granulatus* Leschik, 1955

*Remarks*:— This species was recorded in the writer's previous study of assemblages from the Bundamba Group (de Jersey, 1964, p. 11).

*Distribution*:— Middle Keuper of East Germany (Schulz, 1966); Upper Triassic of Aberdare Conglomerate, Raceview Formation (de Jersey, 1964).

*Duplicisporites* sp. A.

Plate 6, Figure 3

*Description*:— Amb triangular or convexly sub-triangular. No trilete or dehiscence mark observed. Diameter (2 specimens) 33, 48 microns. Three prominent folds or ridges on distal surface, near equator, parallel or subparallel to equatorial margin, width in polar view 3 to 10 microns. Distal exine with dense sculpture of coni, height 1 to 1.5 microns, basal diameter about 1 micron, about 1 micron apart. Proximal exine smooth or with reduced sculpture. Exine (apart from folds or ridges) about 1 or 2 microns in thickness.

*Figured Specimen*:— Slide S2198, stage co-ordinates 19.5, 90.7; diameter 48 microns. Co-ordinates of lower right hand corner of cover glass 27.1, 82.0.

*Locality*:— N.S. 272, 1925 ft., 2 in. (Blackstone Formation).

*Remarks*:— The two specimens recorded differ from previously described species of the genus in having conate sculptural elements. Formal taxonomic designation must await the discovery of additional material.

*Distribution*:— Blackstone Formation, Raceview Formation (this paper).

Genus *GLISCOPOLLIS* Venkatachala, 1966

*Type species*:— *Gliscopollis meyeriana* (Klaus) Venkatachala, 1966.

*Remarks*:— The writer supports the proposal of the new generic name *Gliscopollis* by Venkatachala (1966). Reference should be made to the discussion

of that author (Venkatachala, 1966, p. 99) for an account of the taxonomic history of pollen grains assigned to the genus and an account of the reasons for the use of a new generic name.

*Gliscopollis meyeriana* (Klaus) Venkatachala, 1966

*Selected synonymy*

1960 *Circulina meyeriana* Klaus, p. 165, pl. 36, figs. 57-60.

1964 *Corollina meyeriana* (Klaus) Venkatachala & Góczán, p. 219, pl. 3, figs. 1-5, 21.

1966 *Gliscopollis meyeriana* (Klaus) Venkatachala, 1966, p. 99.

1967 *Corollina meyeriana* (Klaus) Venkatachala & Góczán, in Schulz, 1967, pp. 604, 605, pl. 22, figs. 4-6.

*Remarks*:— The stratigraphic significance of the occurrence of this species in the Bundamba Group is discussed in a later section of this paper.

*Distribution*:— Karnian, Norian and Rhaetian of Austria (Klaus, 1960); Rhaetian of Hungary (Venkatachala and Góczán, 1964); Middle and Upper Keuper and Liassic of East Germany (Schulz, 1966, 1967); Norian and Rhaetian of West Germany and the Netherlands, Rhaetian of England (Geiger and Hopping, 1968); Upper Triassic of Aberdare Conglomerate, Raceview Formation and Ripley Road Sandstone (de Jersey, 1964, this paper).

*Gliscopollis* sp. 1

*Remarks*:— Specimens previously recorded as *Circulina* sp. 1 (de Jersey, 1964, p. 13) should now be assigned to *Gliscopollis*.

*Distribution*:— Raceview Formation (de Jersey, 1964).

Turma PLICATES Naumova *emend.* Potonié, 1960

Subturma POLYPLICATES Erdtman, 1952  
 Gen. nov. A

Plate 6, Figure 8

*Description*:— Pollen grains, consisting of a "central body", of suboval outline, to each extremity of which is attached a large cylindrical protuberance. "Central body" with rounded ends, length 89 microns, breadth 51, 59 microns (2 specimens). Sculpture of "central body" consists of sub-parallel ridges, about 8 or 9 on each face, each 3 or 4 microns in width, separated by intervening grooves about 1.5 microns wide. Ridges converge at longitudinal ends and appear to unite with bases of cylindrical protuberances. Protuberances about 50 microns in length, 8 to 10 microns in diameter for most of their length, except for bulbous extremities which are about 15 microns in diameter.

*Figured specimens*:— Slide S2201, stage co-ordinates 11.1, 93.0; "central body" 89 x 51 microns. Co-ordinates of lower right hand corner of cover glass 27.0, 84.0.



*Locality:*— N.S. 272, 1952 ft., 9 in. (Blackstone Formation).

*Remarks:*— Two complete grains and one fragmentary specimen of this remarkable species have been observed. It is distinct from any genus recorded in literature available to the writer. The closest comparison that can be made is with ephedroid pollen grains, which exhibit a similar pattern of sub-parallel ridges on each face of the grain. Ephedroid grains, assigned to the genus *Equisetosporites* Daugherty *emend.* Pocock and Jansonius, 1964, have been recorded from the Triassic of the Bowen Basin in Queensland (de Jersey and Hamilton, 1967; de Jersey, 1968, 1970). However no ephedroid grains are known which exhibit large terminal protuberances, as in the species recorded here. The interpretation suggested is that the species is gymnospermous and possibly of ephedroid affinity. The function of the large protuberances is a subject for speculation; possibly they were an adaption for water dispersal.

*Distribution:*— Triassic of Blackstone Formation (this paper).

|          |                                                        |
|----------|--------------------------------------------------------|
| Subturma | MONOCOLPATES Wodehouse, Iversen & Troels - Smith, 1953 |
| Genus    | CAMEROSPORITES Leschik <i>emend.</i> Clarke, 1965      |

*Type species:*— *Camerosporites secatus* Leschik, 1955.  
*Camerosporites verrucosus* (de Jersey) *comb. nov. et emend.*

Plate 6, Figures 4, 5, 6, 7.

#### Synonymy

- 1964 *Discisporites verrucosus* de Jersey, pp. 12, 13, pl. 2, figs. 13, 15, 16.  
1967 *Discisporites verrucosus* de Jersey. *in* de Jersey & Hamilton, p. 19, pl. 9, fig. 11.

*Emended diagnosis:*— Amb suboval to subcircular. Larger diameter (based on 110 measured specimens) 21 to 43 microns. On one surface (presumed distal) the exine is smooth and thin, forming a suboval sulcus. Equatorial region thickened for a width of about 2 to 5 microns and ornamented with verrucose or clavate projections, about 1.5 to 4 microns in basal diameter, 1 to 3 microns in height, irregularly distributed. Similar sculptural elements, of similar size or slightly smaller, present on the other (presumed proximal) face, where they are generally about 1 to 2 microns apart, but may be irregularly distributed.

*Figured specimen* (Plate 6, Figure 4):— Slide S2146, stage co-ordinates 24.0, 101.8; diameter 30 microns. Co-ordinates of lower right hand corner of cover glass 27.8, 83.0.

*Locality:*— N.S. 272, 1513 ft., 7 in. (Raceview Formation).

*Figured specimen* (Plate 6, Figure 5):— Slide S2168, stage co-ordinates 25.9, 89.5; dimensions 33 x 26 microns. Co-ordinates of lower right hand corner of cover glass 28.0, 84.7.

*Locality:*— N.S. 272, 1634 ft., 10 in. (Aberdare Conglomerate).

*Figured specimen* (Plate 6, Figures 6, 7 — proximal, distal foci):— Slide No. 320 (Ipswich Coalfield Collection), stage co-ordinates 24.9, 92.6; dimensions 33 x 26 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 83.7.

*Locality:*— N.S. 201, 982 ft., 2 ins. (Aberdare Conglomerate).

*Remarks:*— Study of additional material has led to a re-interpretation of the morphology of this species. The thin area on one face is now interpreted as a distal sulcus, similar to that described by Clarke (1965, p. 313) in *Camerosporites secatus*. The Queensland specimens also resemble that species in their development of verrucose sculptural elements in the equatorial region, which extend on to the proximal face. Structures previously considered to represent a trilete mark (de Jersey, 1964, pp. 12, 13) are now regarded as features resulting from tearing or folding of the thin distal face, which may simulate a trilete mark in some cases. Likewise tearing of the distal exine may produce a thin linear region which resembles a rimula. The present interpretation is supported by study of additional specimens in the light of Clarke's description (1965, p. 313) of the morphologically similar *C. secatus*.

*Camerosporites verrucosus* (de Jersey) *comb. nov.* differs from *C. secatus*, the type and only previously described species of the genus, in having smaller equatorial projections which are less flattened than in that species, and also in having a more sharply defined distal sulcus.

*Distribution:*— Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone, (de Jersey, 1964, this paper); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967).

Genus CYCADOPITES Wodehouse ex Wilson & Webster, 1946

*Type species:*— *Cycadopites follicularis* Wilson and Webster, 1946.

*Cycadopites crassimarginis* (de Jersey) de Jersey, 1964

*Distribution:*— Triassic of Ipswich Coal Measures, Bundamba Group (de Jersey, 1962, 1964, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967).

*Cycadopites granulatus* (de Jersey) de Jersey, 1964

*Distribution:*— Triassic of Ipswich Coal Measures, Bundamba Group (de Jersey, 1962, 1964); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968).



*Cycadopites nitidus* (Balme) de Jersey, 1964

**Remarks:**— *Cycadopites nitidus* is close to the European species *C. acerrimus* (Leschik) Bharadwaj & Singh, 1964, and may be synonymous with it.

**Distribution:**— Widely distributed in the Mesozoic of Australia.

**Queensland Records:**— Jurassic of Walloon Coal Measures, Marburg Sandstone (de Jersey, 1959, 1963); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Triassic of Ipswich Coal Measures, Bundamba Group (de Jersey, 1964, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970).

#### INCERTAE SEDIS

Genus *CIRCULISPORITES* de Jersey *emend.* Norris, 1965

**Type Species:**— *Circulisporites parvus* de Jersey *emend.* Norris, 1965.

**Remarks:**— Potonié (1966, pp. 53, 56) regarded *Circulisporites* as a synonym of *Pseudoschizaea* Thiergart & Frantz, 1961. In doing so, however, he did not take into account Norris's investigation of *Circulisporites* (1965). The latter author has shown (Norris, 1965, pp. 261, 262) that an essential diagnostic feature of *Circulisporites* is the equatorial rupture into two equal hemispheres, each ornamented with a series of concentric ribs. Thiergart and Frantz (1964, p. 84) make no mention of this equatorial rupture in their description of *Pseudoschizaea*; until this feature is demonstrated to be a characteristic of the latter the genera cannot be united. An additional difficulty in the interpretation of *Pseudoschizaea* is the lack of a separate generic diagnosis; the validity of this monotypic genus is doubtful in terms of Articles 41 and 42 of the International Code of Botanical Nomenclature (1966).

*Circulisporites parvus* de Jersey *emend.* Norris, 1965

Plate 5, Figure 6

**Figured specimen:**— Slide S2203, stage co-ordinates 16.0, 90.4; diameter 18 microns. Co-ordinates of lower right hand corner of cover glass 27.8, 83.7.

**Locality:**— N.S. 272, 2389 ft., 8 in. (Blackstone Formation).

**Remarks:**— The illustration (Plate 5, Figure 6) is an oblique polar view of a complete specimen of this species; it shows the overlapping of the concentric rib patterns on both hemispheres.

**Distribution:**— Triassic of Ipswich Coal Measures (de Jersey, 1962, this paper); Upper Triassic of Bundamba Group (de Jersey, 1964); Triassic of Tingalpa Formation, Brisbane area (de Jersey and Hamilton,

1965b); Triassic of Tasmania (Playford, 1965); Jurassic of Marburg Sandstone (de Jersey, 1963); Jurassic of Evergreen Formation and Hutton Sandstone (de Jersey and Paten, 1964); Triassic of Beacon Group, Antarctica (Norris, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967).

#### MICROFLORAL SEQUENCE IN THE SECTION STUDIED

As indicated in the preceding Stratigraphic Discussion, the section covered by the samples from N.S. 272 extends from the basal part of the Blackstone Formation to the top of the Raceview Formation. Assemblages from these samples are listed in the Appendix; the stratigraphic distribution of species is illustrated in the Microfloral Distribution Chart (Figure 2), in which the lithology of the section is also indicated. The samples selected for the investigation were of fairly uniform lithology (grey, slightly carbonaceous shale). Such uniformity in lithology has, it is believed, minimised the influence of facies variation on the assemblages.

Study of the Microfloral Distribution Chart (Figure 2) indicates that many species and genera range throughout the sequence. In particular, bisaccate pollen grains of the *Pteruchus* type (*Disaccites* spp.) are abundant, or dominant, in most of the assemblages. The abundance of these grains is a characteristic feature of microfloras from the greater part of the Triassic System in Queensland. However, within the limits of the section studied, their distribution appears to lack stratigraphic significance. Other forms, which are long-ranged, in the section studied, are indicated in Figure 2. They include many distinctive and widespread species; among these are *Annulispora microannulata*, *Converrucosisporites cameroni*, *Dictyophyllidites mortoni*, *Duplexisporites problematicus*, *Polycingulatisporites densatus* and *Polypodiisporites ipsviciensis*. The occurrence of so many species, which range through the disconformity between the Blackstone Formation and the overlying Bundamba Group, favours the view that the time break, represented by this disconformity, was of relatively short duration.

Apart from such long-ranged species, study of Figure 2 indicates that some of the species are restricted to portions of the sequence studied. Of these, particular significance is attached to species which first appear above the disconformity at the base of the Bundamba Group, as they comprise elements of a younger microflora appearing within the Late Triassic. They include *Foveosporites moretonensis*, *Gliscopollis meyeriana*, *Lycopodiumsporites rosewoodensis*, *Polycingulatisporites crenulatus*, and *P. mooniensis*. Within this group, the species which is likely to prove most useful in correlation studies is *P. crenulatus*. This species first appears in the assemblage from the Aberdare Conglomerate; the lower limit of its range thus substantially coincides with the disconformity at the base of the Bundamba Group. Moreover its persistence in the assemblages recorded enhances its potential value in



correlation studies. This persistence is indicated by its presence in five of the seven assemblages recorded from the Aberdare Conglomerate and Raceview Formation.

Other species, of restricted range within the section studied, comprise mainly those which are recorded from the Blackstone Formation and do not extend into the overlying Bundamba Group. They include *Aratrisporites banksi*, *A. flexibilis*, *Semiretisporis denmeadi*, and the less common *Distalanulisporites* cf. *punctus*, *Stereisporites* sp. A, and Gen. nov. A. The presence of any of these species in an assemblage would accordingly favour correlation with the Ipswich Coal Measures, rather than with the Bundamba Group.

### COMPARISON WITH OTHER AUSTRALIAN TRIASSIC MICROFLORAS

Data on microfloral assemblages, recorded in the present investigation, provide a basis for comparison with assemblages described from Queensland and from other parts of Australia. In Queensland, Triassic microfloras have been recorded from the Ipswich Coal Measures (de Jersey, 1962); Bundamba Group (de Jersey, 1964); Mount Crosby Formation (de Jersey and Hamilton, 1965a); Moorooka and Tingalpa Formations, Brisbane area (de Jersey and Hamilton, 1965b); Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968) and Rewan Formation (de Jersey, 1970).

As indicated above, the present study has supplemented and extended knowledge of microfloras from the Ipswich Coal Measures and Bundamba Group, previously recorded by de Jersey (1962, 1964) and de Jersey and Hamilton (1965a). Beyond the area of the Ipswich coalfield, Triassic microfloras from the adjacent Brisbane area have been examined by de Jersey and Hamilton (1965b). Samples studied from the Brisbane area came from four drillholes in the Moorooka and Tingalpa Formations. It was concluded (de Jersey and Hamilton, 1965b, p. 332) that assemblages from these samples were generally indicative of correlation with the Ipswich Coal Measures, rather than with the Bundamba Group. However, it was emphasised that additional data on microfloras from shale, as well as coal samples, from the Ipswich Coal Measures were required to support this correlation and to provide a basis for comparison with stratigraphic units within the Ipswich sequence.

This additional information has been supplied by the present investigation. Data now available support the correlation indicated, in the case of material from three of the four drillholes, comprising eleven of the twelve assemblages recorded. Assemblages from these three drillholes include *Semiretisporis denmeadi*, which has been found in the Tivoli and Blackstone Formations, but not in the Bundamba Group, and lack *Polycingulatisporites crenulatus*, which first appears at the base of the Bundamba sequence. The present, more detailed evidence thus supports the previous correlation, in the case of these assemblages. The remaining assem-

blage, from the Moorooka Formation in N.S. 17 (de Jersey and Hamilton, 1965b, p. 331) does not include either of these species. Consequently in the light of present knowledge further palynological evidence is required on correlation of the Triassic sediments in this drillhole, which is the most easterly of those from which samples were studied.

Triassic microfloras have also been recorded from the Bowen Basin, in Queensland. In descending stratigraphic order, assemblages from the Moolayember Formation, Clematis Sandstone and Rewan Formation were described by de Jersey and Hamilton (1967) and de Jersey (1968, 1970). Microfloras from the sub-surface Wandoan Formation have also been recorded (de Jersey and Hamilton, 1969). On the basis of microfloral and lithological evidence, it was concluded that the Wandoan sediments constitute a sub-surface development of the Clematis - lower Moolayember portion of the Bowen Basin sequence (de Jersey and Hamilton, 1969, pp. 3, 4).

From a previous comparison of assemblages from the Bowen Basin with those from the Ipswich-Bundamba sequence it was suggested (de Jersey and Hamilton, 1967, p. 23) that the Moolayember Formation (and hence the entire Triassic sequence of the Bowen Basin) was pre-Ipswich in age. This suggestion is supported by the present more detailed knowledge of the Ipswich and Bundamba microfloras. Moolayember species, which are absent in assemblages recorded from the Ipswich - Bundamba sequence, include *Accinctisporites ligatus*, *Aratrisporites plicatus*, *A. strigosus*, *A. wollariensis*, *Cadargasporites senectus*, *Densoisporites playfordi*, *Grebesspora concentrica*, *Kraeuselisporites verrucifer*, *Nevesisporites limatus*, *Rugulatisporites stonecrofti*, *R. trisinus*, *Tigrisporites playfordi* and *Verrucosisporites carnavonensis*. Species from the Blackstone Formation, which have not been recorded in the Moolayember assemblages, include *Acanthotriletes bradiensis*, *Anapiculatisporites pristidetatus*, *Annulispora folliculosa*, *A. microannulata*, *Apiculatisporis globosus*, *Aratrisporites flexibilis*, *Baculatisporites comaumensis*, *Cadargasporites baculatus*, *Craterisporites rotundus*, *Duplicisporites* sp. A., *Polycingulatisporites densatus*, *Pustulatisporites blackstonensis*, *Semiretisporis antiquus*, *Stereisporites perforatus*, *S.* sp. A and Gen. nov. A.

From these lists it will be evident that there are marked differences between the Blackstone and Moolayember assemblages. These differences are considered to be too great to be explained solely by facies differences, particularly when so many assemblages from samples of varied lithology have been studied from each sequence. The alternative explanation, that the Moolayember Formation is distinctly older than the Blackstone Formation, seems a far more likely reason to explain these marked differences in the assemblages. Such a view is strongly supported by consideration of the known ranges of the species listed, which leads to the conclusion that a significant proportion of the Moolayember species have been replaced in the Blackstone assemblages by younger elements, many of which extend into the overlying Bundamba Group.



In New South Wales, Helby (1967) has described a microflora from the Wollar Sandstone. As indicated previously (de Jersey, 1970, p. 26) this microflora is comparable with those from the uppermost Rewan Formation or basal Clematis Sandstone. It contains species such as *Aratrisporites wollariensis*, *Aratrisporites tenuispinosus*, *Cyathidites breviradiatus* and *Kraeuselisporites differens*, which are absent from the Ipswich-Bundamba assemblages and, on the other hand, lacks many of the species present in the latter. Clearly this microflora from the Wollar Sandstone is distinctly older than the assemblages from the Ipswich-Bundamba sequence. The assemblage from Permian-Triassic transition beds in the Sydney Basin, described by Hennelly (1958) is of even earlier aspect, and separated by a long time interval from the Ipswich microflora, with which it has little in common. Also in New South Wales, Triassic assemblages from the Narrabeen Group, Hawkesbury Sandstone and Wianamatta Group are currently being studied by Mr. R. Helby. Detailed comparison with the Ipswich-Bundamba microfloras must await publication of this work on the Sydney Basin.

From Tasmania, Playford (1965) has described a suite of microfloras, comprising assemblages of Early Middle, and Late Triassic age. Microfloras from the Ipswich-Bundamba sequence show closest similarity to assemblages from the Brady Formation and "Feldspathic Sandstone", which he regarded as Late Triassic in age (Playford, 1965, p. 203). This similarity is indicated by the presence of a number of species common to assemblages from both areas, including *Acanthotriletes bradiensis*, *Annulispora folliculosa*, *Apiculatisporis globosus*, *Baculatisporites comaumensis*, *Duplexisporites problematicus*, *Neoraistrickia taylorii*, *Semiretisporis denmeadi* and *Stereisporites perforatus*. Correlation with some part of the Ipswich-Bundamba sequence is accordingly indicated for these Tasmanian assemblages. More precise correlation is difficult, because of incomplete knowledge of the latter, but the presence of *A. bradiensis* and *S. denmeadi* and absence of *Polycingulatisporites crenulatus* and of any other species restricted to the Bundamba assemblages, provide evidence favouring correlation with the Ipswich Coal Measures, rather than with the overlying Bundamba Group.

Microfloras described from the Leigh Creek Coal Measures of South Australia (Playford and Dettmann, 1965) are also comparable with those from the Ipswich-Bundamba sequence. Playford and Dettmann (1965, pp. 161-164) divided the Leigh Creek assemblages into two groups, comprising an older microflora, of Triassic aspect, and a younger Liassic group of assemblages. The older microflora contains *Aratrisporites flexibilis*, *Semiretisporis denmeadi* and other long-ranged species; it is most closely comparable with assemblages from the Ipswich Coal Measures. The younger assemblages from the overlying sediments are distinguished by the incoming of *Classopollis classoides*, *Foraminisporis tribulosus*, *Lycopodiumsporites austroclavatidites* and *Polycingulatisporites crenulatus*. They are, in general terms, of Liassic aspect and similar to

assemblages from the Precipice Sandstone of the Surat Basin, regarded as probably Liassic (de Jersey and Paten, 1964; Reiser and Williams, 1969).

An interesting feature of this Leigh Creek succession is that it does not appear to include any assemblages of intermediate aspect, such as characterize the lower part of the Bundamba Group (the Aberdare Conglomerate and Raceview Formation). Such assemblages contain *Gliscopollis meyeriana*, *Lycopodiumsporites rosewoodensis*, *Polycingulatisporites crenulatus* and *P. mooniensis*, but lack *Classopollis classoides* and *Lycopodiumsporites austroclavatidites* and are thus intermediate between assemblages from the Blackstone Formation and those of the Precipice Sandstone. It is accordingly suggested that the Leigh Creek succession may have within it a concealed hiatus between sediments containing the older, Triassic microflora and strata which yield the younger assemblages, of Liassic aspect. Alternatively, deposition of the sediments at Leigh Creek may have taken place at a much slower rate than was the case for sediments of the Ipswich-Bundamba sequence. A solution of the problem, which would explain the apparent absence of Raceview-type assemblages from the Leigh Creek sequence, must await more detailed study of the biostratigraphy of the latter, to supplement and extend the initial study of Playford and Dettmann.

Finally, a Lower Triassic microflora from the Kockatea Shale of Western Australia has been described by Balme (1963). This microflora contains distinctive species of *Densoisporites*, *Kraeuselisporites*, *Lundbladisporea* and *Striatissaccus* which characterize Australian assemblages of this age. In Queensland similar assemblages have been recorded from part of the Rewan Formation and are regarded as approximately contemporaneous with the Kockatea microflora (de Jersey, 1970). The assemblages are very different from the Ipswich-Bundamba microfloras; evidently most of the Early Triassic elements were replaced by other genera and species, later in the Triassic.

### AGE OF THE MICROFLORAS

Microfloral evidence on the age of the Ipswich Coal Measures and Bundamba Group has been discussed in a previous paper (de Jersey, 1964, pp. 18, 19). From the evidence then available, a Late Triassic age (Carnian-Norian) was suggested for the Bundamba Group and a Middle to Late Triassic age (Ladinian-Carnian) for the underlying Ipswich Coal Measures. Since 1964, much additional information has accumulated on biostratigraphic aspects of Triassic microfloras from Australia, Europe and elsewhere. This additional information, considered in conjunction with the present study of additional material from the Ipswich-Bundamba sequence, provides scope for re-assessment of the ages of the Ipswich and Bundamba microfloras.

As far as the Bundamba assemblages are concerned, an important result of the present study has been the discovery, in material from the Raceview Formation and Aberdare Conglomerate, of several species previously recorded from the Precipice Sandstone of the Surat Basin. The discovery of these species has resulted



from the application of specific gravity separation in processing the maceration residues; the improved yields of plant microfossils (relative to other components of the maceration residues) have enabled much more detailed study of the rarer elements of microflora. The species concerned comprise *Anapiculatisporites pristidentatus*, *Baculatisporites comaumensis*, *Cadargasporites granulatus*, *C. reticulatus*, *Camerozonosporites rudis*, *Lycopodiumsporites rosewoodensis*, *Polycingulatisporites crenulatus* and *P. mooniensis*. These species have all been previously recorded from the Precipice Sandstone, regarded as probably Liassic in age (Reiser and Williams, 1969, p. 22). Their presence in the Bundamba assemblages strengthens the relationship to this Early Jurassic microflora and favours the view that the Aberdare - Raceview assemblages represent a later time interval, within the Late Triassic, than previously believed.

Further evidence on the age of the Bundamba microfloras is provided by comparison with assemblages recorded from the Late Triassic of Europe. Recent papers pertinent to this comparison are those by Geiger and Hopping (1968), and Schulz (1966, 1967). The former authors have studied the distribution of 25 selected palynomorphs, and their use as guide-fossils in sub-dividing the Triassic succession of north-western Europe. Among these are the species *Gliscopollis meyeriana* (formerly recorded as *Circulina meyeriana*) and the genus *Classopollis*. Concerning the former, Geiger and Hopping state (1968, p. 32) "Klaus (1960) has given the stratigraphical range of *C. meyeriana* as Norian, Rhaetian, and early Jurassic. Certainly the species has not been found in association with *Camerosporites secatus* and Klaus in his extensive and thorough palynological studies of the Carnian has only recorded one specimen". Thus it appears that for purposes of regional correlation, the extremely rare occurrence of this species in the Carnian can be ignored and the commencement of its range taken as essentially at the base of the Norian. Geiger and Hopping also provide data on the incoming of the genus *Classopollis*. They record the first appearance of this genus within an interval, from basal Rhaetian to basal Liassic, in the European sections studied. Thus from this evidence the Aberdare-Raceview assemblages, which contain *G. meyeriana* and are lacking in *Classopollis*, should be regarded as Norian or Rhaetian in age.

Other species which are common to both European and Queensland microfloras are *Lycopodiumsporites austroclavatidites*, *Perinopollenites elatoides* and *Polycingulatisporites crenulatus*. All these make their first appearance in the Rhaetian of Europe. In Queensland, *P. crenulatus* is known from the basal part of the Bundamba Group, but *L. austroclavatidites* and *P. elatoides* are first recorded only from the younger Precipice Sandstone. The presence of some Rhaetian species, but not others, may indicate slight divergence in the ranges of the species, between Europe and Australia. However, the presence of *P. crenulatus*, in particular, constitutes positive evidence that the Aberdare-Raceview microfloras are Rhaetian or, alternatively, unlikely to be older than Norian.

The various lines of evidence thus support each other in indicating a Late Triassic age for assemblages from the Aberdare Conglomerate and Raceview Formation. Within the Late Triassic, the evidence now available favours a Norian or Rhaetian, rather than a Carnian age.

The investigation has also led to a further appraisal of the age of the Blackstone Formation, at the top of the Ipswich Coal Measures. Four European species — *Apiculatisporites globosus*, *Aratrisporites parvispinosus*, *Baculatisporites comaumensis*, and *Stereisporites perforatus* — are recorded from the Blackstone assemblages. Of these, *B. comaumensis* first appears in the upper Muschelkalk and *Apiculatisporites globosus*, *Aratrisporites parvispinosus*, and *Stereisporites perforatus* are first recorded from the Middle Keuper. The presence of these species gives a Late Triassic aspect to the Blackstone assemblages. Within the Late Triassic, the absence of any record of *Gliscopollis meyeriana* favours a Carnian, rather than a Norian or Rhaetian age. The evidence for a Late Triassic age is not yet entirely conclusive, but is supported by the absence of a number of species which are present in the Moolayember Formation, a unit which is regarded as Middle Triassic (de Jersey and Hamilton, 1967, p. 24).

The above conclusions on the age of the microfloras should be regarded as constituting a progress report, based on the evidence now available. It is likely that additional data will be forthcoming from studies of the microfloras of the lower part of the Ipswich Coal Measures (underlying the Blackstone Formation) and of the upper part of the Bundamba Group (the Ripley Road Sandstone, overlying the Raceview Formation). Perhaps the most interesting result of the present investigation has been the discovery in the Raceview Formation of several species previously known from the younger (Liassic) Precipice Sandstone. The discovery of these species indicates the possibility of a gradual transition from the Late Triassic Raceview assemblages to Liassic-type microfloras, which characterize the Precipice Sandstone. This possibility of a gradual transition, instead of the more abrupt change suggested by earlier evidence, supports the view that a conformable, gradational succession spanning the Triassic-Jurassic boundary may eventually be demonstrated in south-eastern Queensland.

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## PLATE 1

(All photographs approximately X1000)

- Figure 1—*Stereisporites antiquasporites* (Wilson & Webster)  
Dettmann, 1963 (median focus).
- Figure 2—*Stereisporites perforatus* Leschik, 1955 (distal  
focus).
- Figure 3—*Stereisporites* sp. A (median focus).
- Figure 4—*Clavatriletes* sp. cf. *C. hammenii* Herbst, 1965  
(proximal focus).
- Figure 5—*Clavatriletes* sp. cf. *C. hammenii* Herbst, 1965  
(distal-equatorial focus, same specimen as figure  
4).
- Figure 6—*Clavatriletes* sp. cf. *C. hammenii* Herbst, 1965  
(distal-equatorial focus).
- Figure 7—*Craterisporites rotundus* sp. nov. (median focus).
- Figure 8—*Craterisporites rotundus* sp. nov. (Holotype, distal  
focus).
- Figure 9—*Craterisporites rotundus* sp. nov. (median focus).



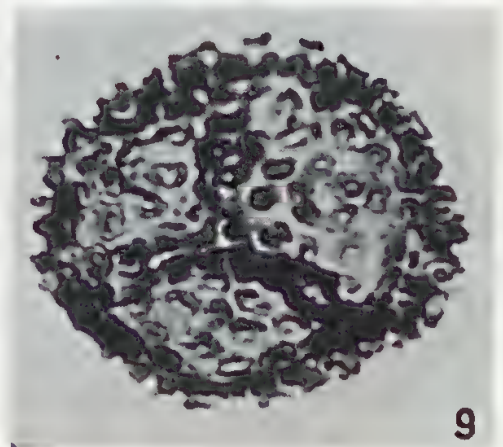
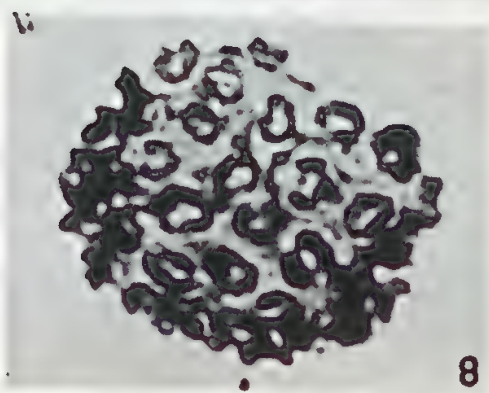
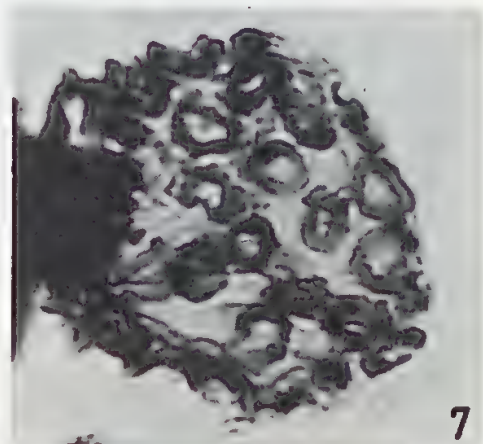
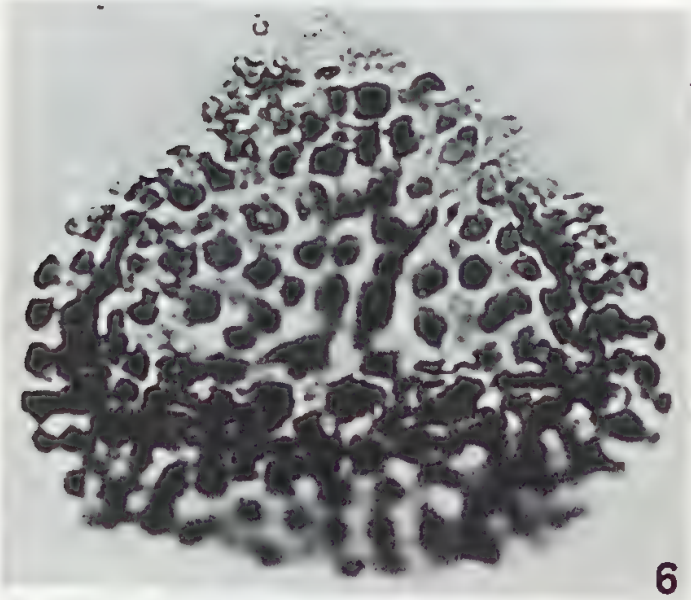
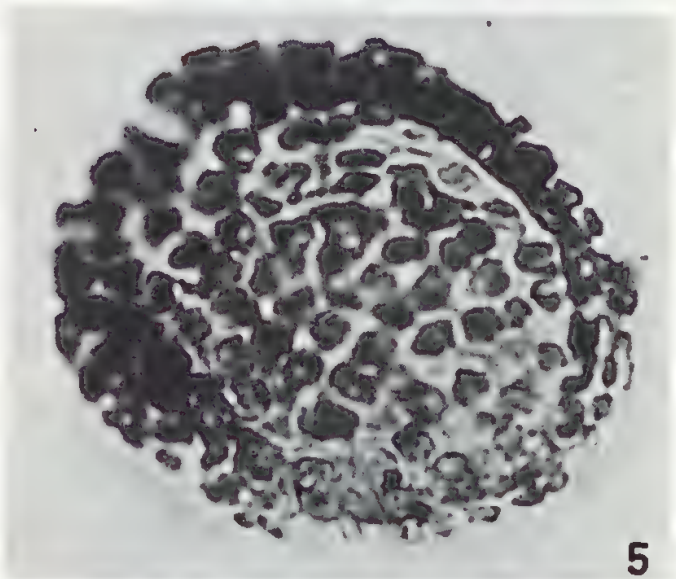
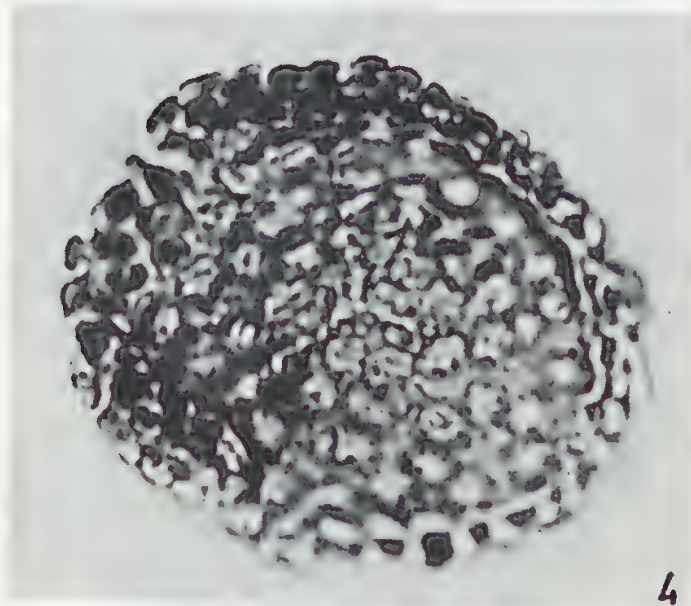
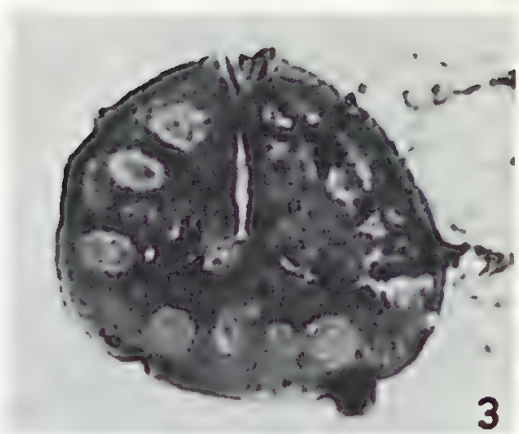


PLATE 1

## PLATE 2

(All photographs approximately X1000)

- Figure 1—*Apiculatisporis globosus* (Leschik) Playford and Dettmann, 1965 (median focus).
- Figure 2—*Pustulatisporites blackstonensis* sp. nov. (Holotype, median focus).
- Figure 3—*Lophotriletes* sp. cf. *L. baubini* de Jersey and Hamilton, 1967 (equatorial focus).
- Figure 4—*Pustulatisporites blackstonensis* sp. nov. (median focus).
- Figure 5—*Neoraistrickia taylorii* Playford and Dettmann, 1965 (equatorial focus).
- Figure 6—*Baculatisporites comaumensis* (Cookson) Potonié, 1956 (equatorial focus).



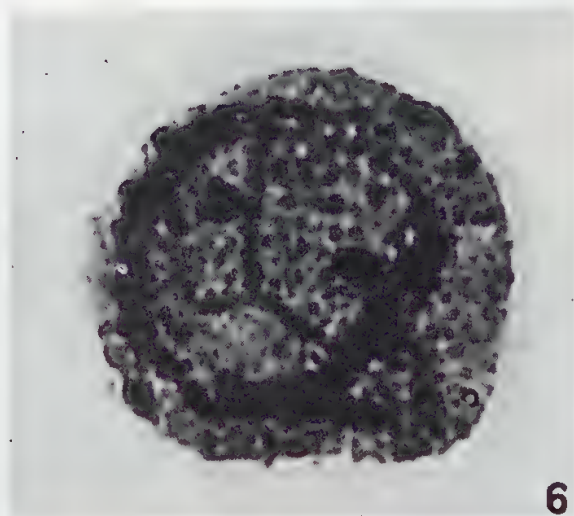
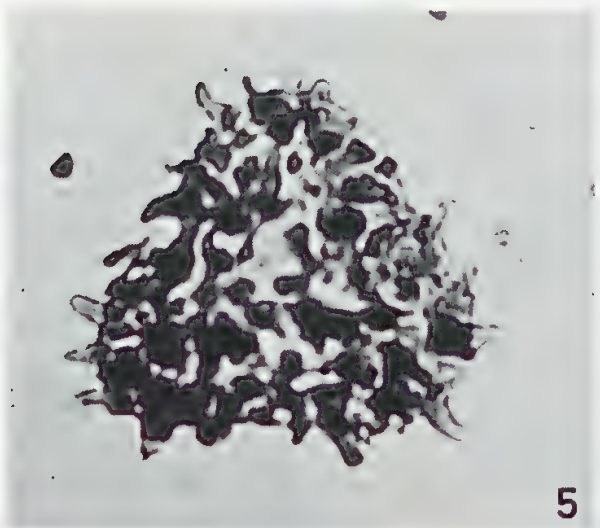
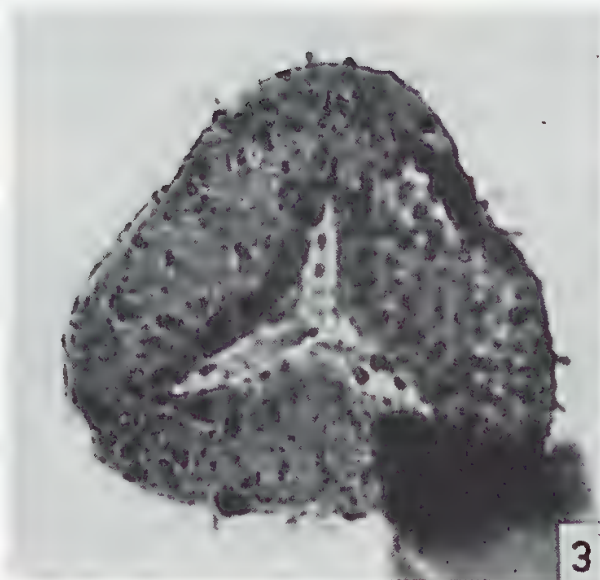
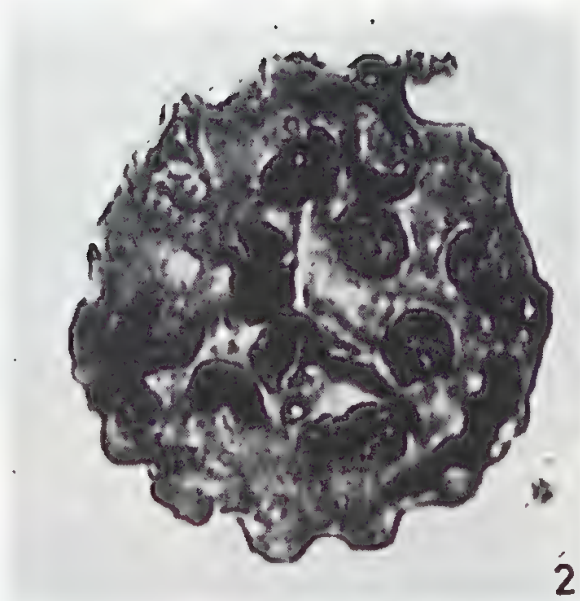
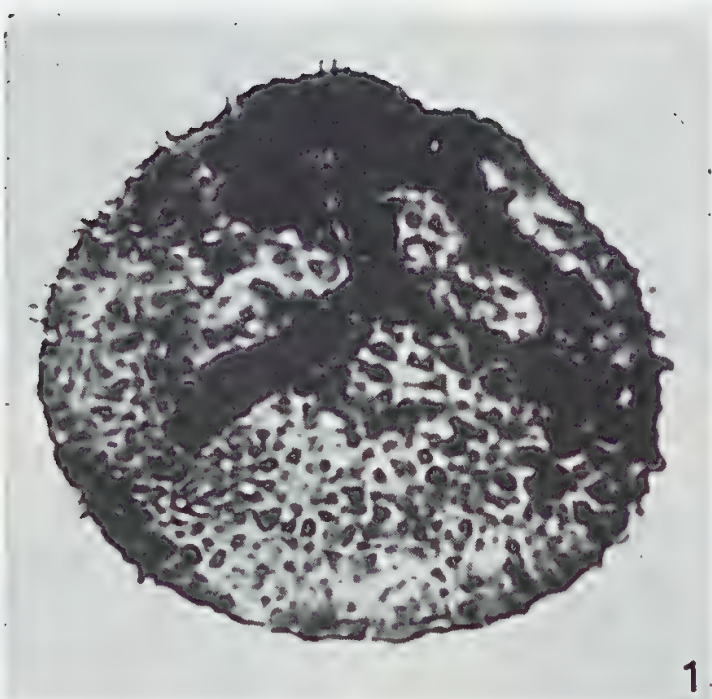


PLATE 2

### PLATE 3

(All photographs approximately X1000)

- Figure 1—*Duplexisporites problematicus* (Couper) Playford and Dettmann, 1965 (distal focus).
- Figure 2—*Duplexisporites problematicus* (Couper) Playford and Dettmann, 1965 (distal focus).
- Figure 3—*Duplexisporites problematicus* (Couper) Playford & Dettmann, 1965 (distal focus).
- Figure 4—*Foveosporites moretonensis* de Jersey, 1964 (distal focus).
- Figure 5—*Lycopodiumsporites rosewoodensis* (de Jersey) de Jersey, 1963 (distal focus).
- Figure 6—*Annulispota microannulata* de Jersey, 1962 (median focus).
- Figure 7—*Camarozonosporites rudis* (Leschik) Klaus, 1960 (median focus).
- Figure 8—*Distalanulisorites* sp. cf. *D. punctus* Klaus, 1960 (median focus).
- Figure 9—cf. *Densosporites* sp. (median focus).
- Figure 10—*Polycingulatisporites crenulatus* Playford and Dettmann, 1965 (median focus).
- Figure 11—*Polycingulatisporites crenulatus* Playford and Dettmann, 1965 (distal-equatorial focus).
- Figure 12—*Polycingulatisporites crenulatus* Playford and Dettmann, 1965 (median focus).



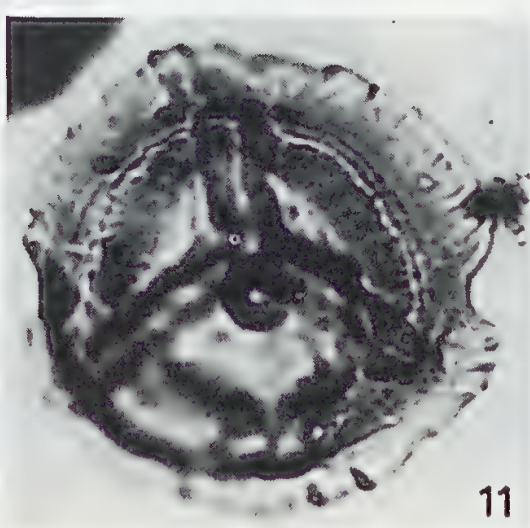
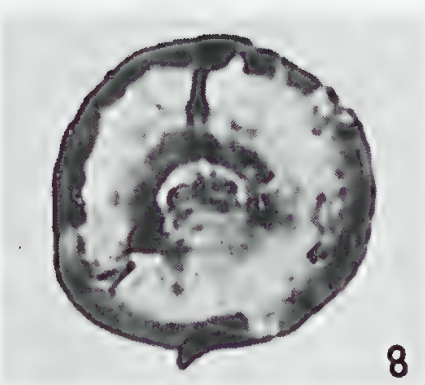
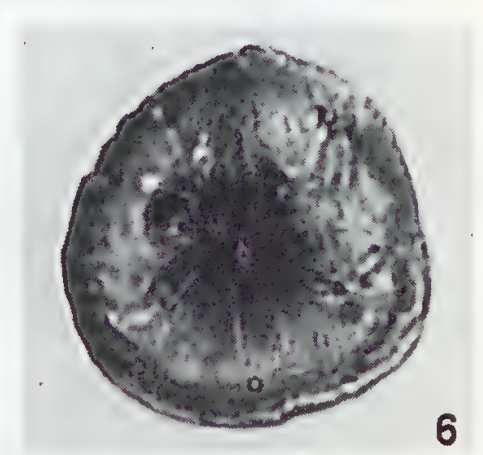
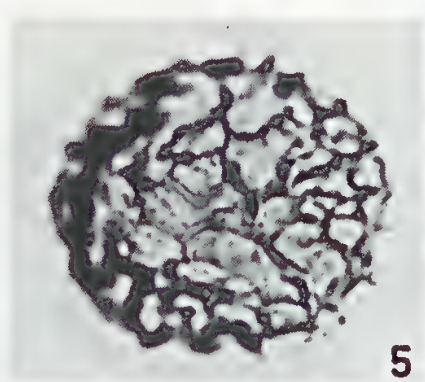
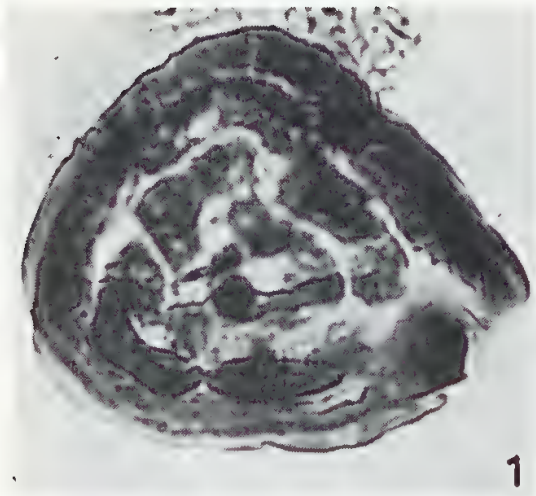


PLATE 3

#### PLATE 4

(All photographs approximately X1000)

- Figure 1—*Polycingulatisporites crenulatus* Playford and Dettmann, 1965 (median focus).
- Figure 2—*Polycingulatisporites densatus* (de Jersey) Playford and Dettmann, 1965 (median focus).
- Figure 3—*Polycingulatisporites mooniensis* de Jersey and Paten, 1964 (median focus).
- Figure 4—*Semiretisporis antiquus* (de Jersey) comb. nov. (distal focus).
- Figure 5—*Semiretisporis antiquus* (de Jersey) comb. nov. (distal-equatorial focus).
- Figure 6—*Semiretisporis antiquus* (de Jersey) comb. nov. (distal focus).
- Figure 7—*Semiretisporis antiquus* (de Jersey) comb. nov. (distal-equatorial focus).
- Figure 8—*Semiretisporis denmeadi* (de Jersey) comb. nov. (distal focus).
- Figure 9—*Anapiculatisporites pristidentatus* Reiser and Williams, 1969 (distal-equatorial focus).



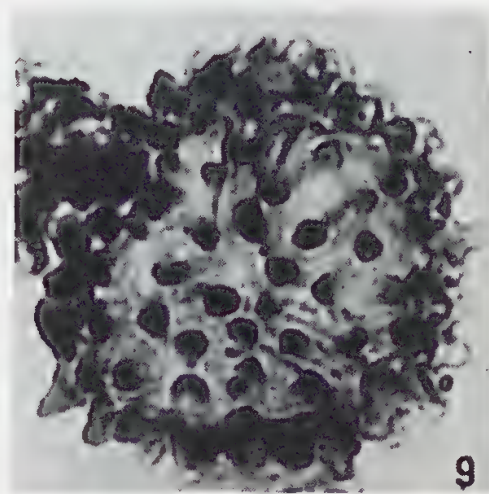
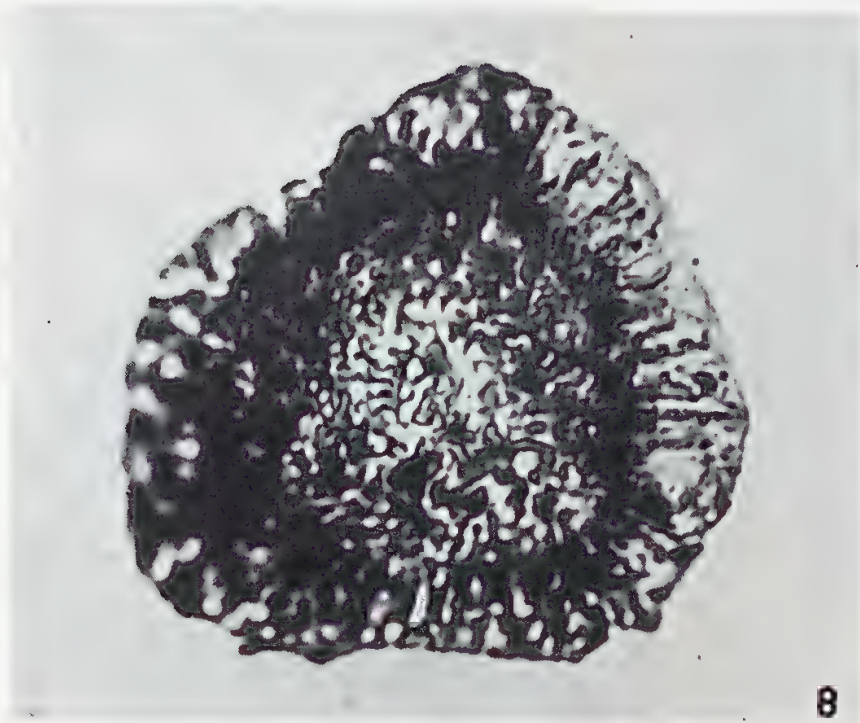
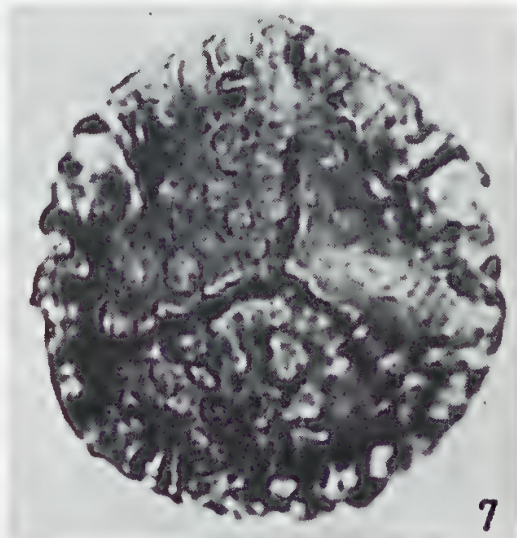
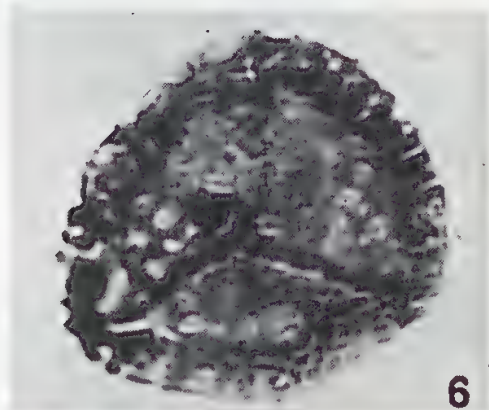
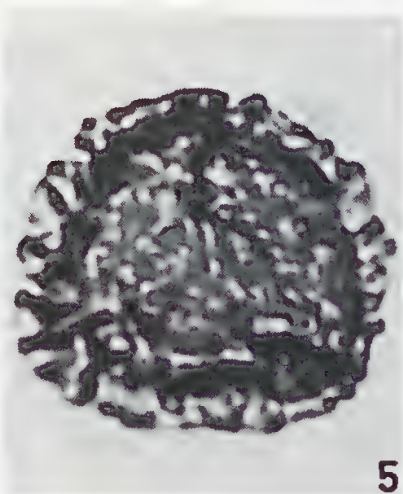
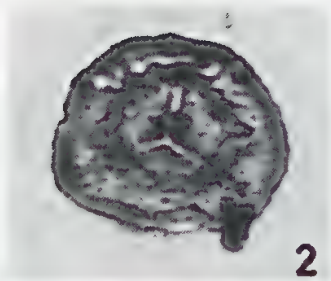


PLATE 4

## PLATE 5

(All photographs approximately X1000, unless otherwise stated)

- Figure 1—*Cadargasporites baculatus* de Jersey and Paten *emend.* Reiser and Williams, 1969 (proximal focus).
- Figure 2—*Cadargasporites reticulatus* de Jersey and Paten, 1964 (lateral view).
- Figure 3—*Aratrisporites flexibilis* Playford and Dettmann, 1965 (equatorial focus).
- Figure 4—*Aratrisporites banksi* Playford, 1965 (equatorial focus).
- Figure 5—*Conaletes* sp. (X1500) (equatorial focus).
- Figure 6—*Circulisporites parvus* de Jersey *emend.* Norris, 1965 (X1500) (oblique polar view).



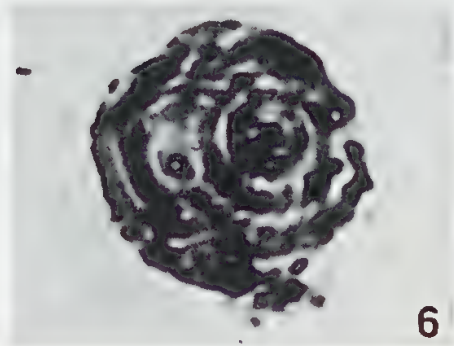
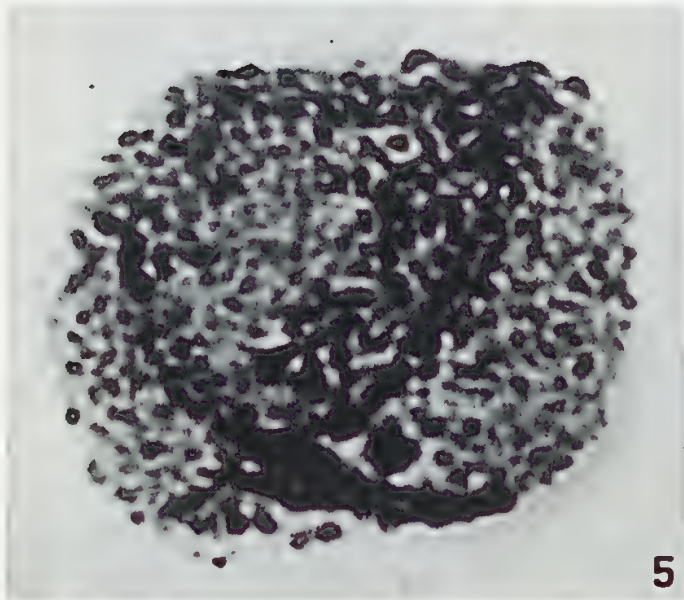
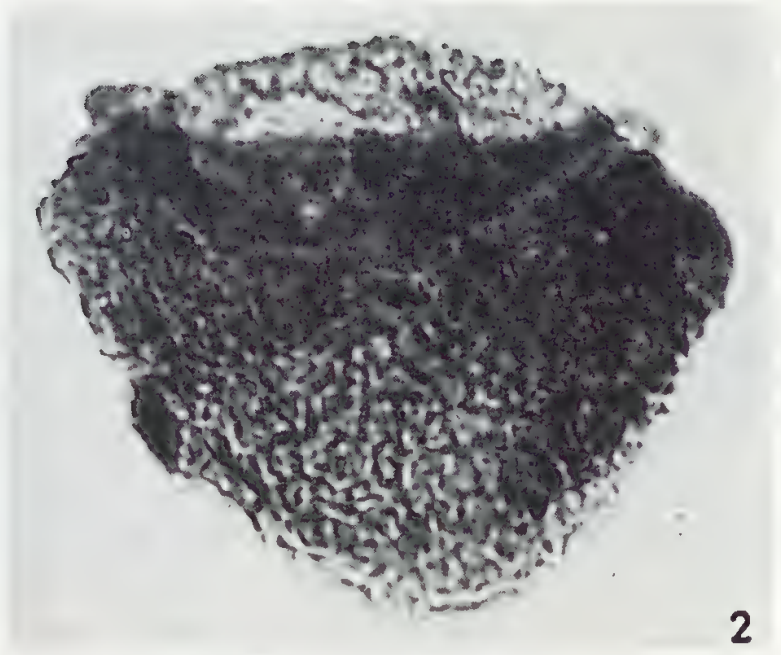


PLATE 5

## PLATE 6

(All photographs approximately X1000, unless otherwise stated)

- Figure 1—*Chordasporites australiensis* de Jersey, 1962 (median focus).
- Figure 2—*Sulcosaccispora alaticonformis* (Malyavkina) de Jersey, 1968 (median focus).
- Figure 3—*Duplicisporites* sp. A (distal-equatorial focus).
- Figure 4—*Camerosporites verrucosus* (de Jersey) comb. nov. (proximal-equatorial focus).
- Figure 5—*Camerosporites verrucosus* (de Jersey) comb. nov. (proximal-equatorial focus).
- Figure 6—*Camerosporites verrucosus* (de Jersey) comb. nov. (proximal focus).
- Figure 7—*Camerosporites verrucosus* (de Jersey) comb. nov. (distal focus; same specimen as figure 6).
- Figure 8—Gen. nov. A (X750) (median focus).



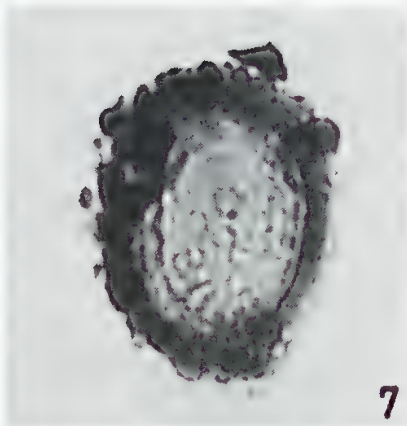
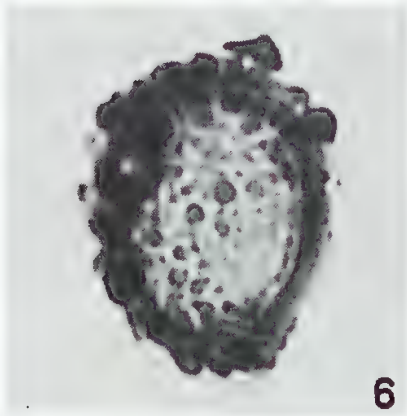
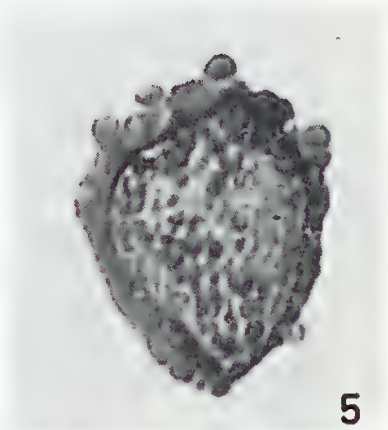
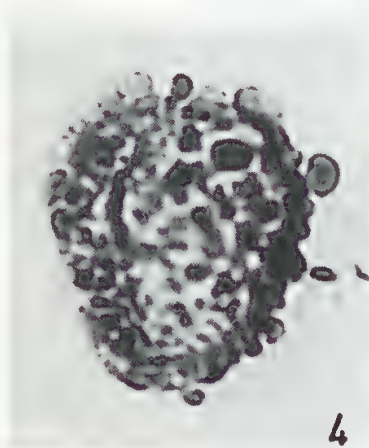
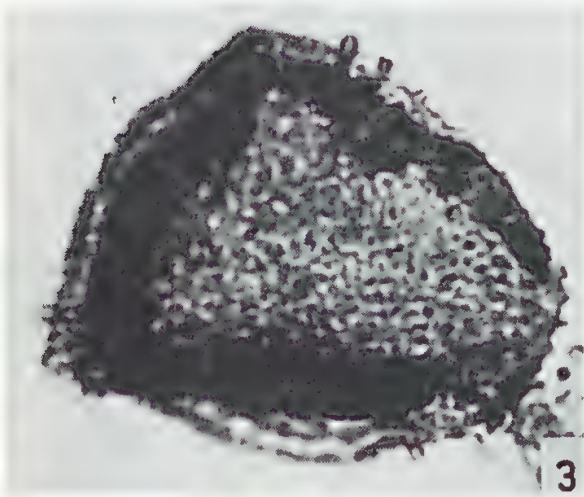
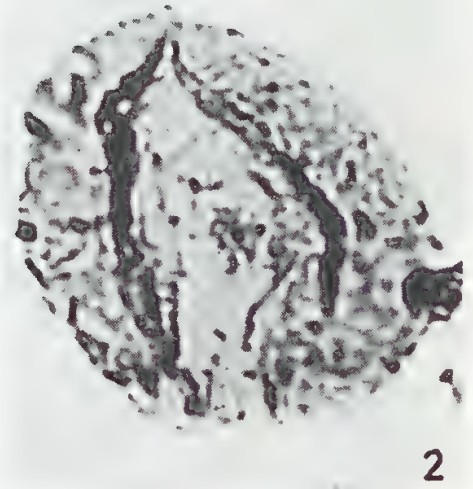


PLATE 6



## APPENDIX — Lists of Microfloral Assemblages

The assemblages recorded below are arranged in ascending stratigraphic order. The samples examined all consisted of grey shale, with varying proportions of carbonaceous matter. Figures in the headings of the various samples indicate that counts of those magnitudes were made; addition of the + sign, e.g. 200+, indicates that an additional low power traverse was made of each of the available slides. Species recorded only in such additional traverses are indicated by the sign + in each list. Indeterminate specimens have not been included.

## BLACKSTONE FORMATION

## N.S. 272, 2400 ft., 5 in. No count

cf. *Accinctisporites* sp.  
*Anapiculatisporites pristidentatus*  
*Chordasporites australiensis*  
*Clavatriletes* cf. *hammenii*  
*Converrucosisporites cameroni*  
*Craterisporites rotundus*  
*Cycadopites nitidus*  
*Duplexisporites problematicus*  
*Guthoerlisporites cancellosus*  
*Leiotriletes directus*  
*Osmundacidites* sp.  
*Punctatisporites* sp.  
*Pustulatisporites blackstonensis*  
*Semiretisporis antiquus*  
*Semiretisporis denmeadi*  
*Disaccites* spp. (indet.)

## N.S. 272, 2389 ft., 8 in. Count 200+

cf. *Accinctisporites* sp. .... +  
*Annulispora microannulata* .... +  
*Biretisporites* sp. .... +  
*Calamospora tener* .... +  
*Chordasporites* sp. .... 0.5%  
*Circulisporites parvus* .... 0.5%  
*Converrucosisporites cameroni* .... 0.5%  
*Craterisporites rotundus* .... +  
*Cycadopites* sp. .... +  
*Cycadopites nitidus* .... 0.5%  
*Dictyophyllidites mortoni* .... +  
*Duplexisporites problematicus* .... 1.0%  
*Guthoerlisporites cancellosus* .... +  
*Indusiisporites* sp. .... +  
cf. *Kraeuselisporites* sp. .... +  
*Leiotriletes directus* .... 0.5%  
*Neoraistrickia taylorii* .... +  
*Neoraistrickia* cf. *taylorii* .... 0.5%  
*Neoraistrickia* sp. .... 0.5%  
*Osmundacidites wellmanii* .... 0.5%  
*Platysaccus queenslandi* .... 0.5%  
*Polycingulatisporites densatus* .... +  
*Polypodiisporites ipsviciensis* .... 1.5%  
*Semiretisporis denmeadi* .... +  
*Stereisporites antiquasporites* .... +  
*Stereisporites perforatus* .... +  
*Stereisporites* sp. A .... +  
*Sulcosaccispora alaticonformis* .... +  
*Vitreisporites pallidus* .... 0.5%  
*Disaccites* spp. (indet.) .... 92.5%

## N.S. 272, 2289 ft., 8 in. Count 200+

*Apiculatisporis* spp. .... 1.0%  
*Aratrisporites banksi* .... +  
*Aratrisporites flexibilis* .... +  
*Baculatisporites comaumensis* .... +  
*Camerosporites verrucosus* .... +  
*Chordasporites* sp. .... 0.5%  
*Clavatriletes* cf. *hammenii* .... +  
*Craterisporites rotundus* .... 0.5%  
*Cycadopites nitidus* .... 9.0%  
*Cycadopites* sp. (indet.) .... 1.0%  
*Duplexisporites problematicus* .... 6.5%  
*Guthoerlisporites cancellosus* .... +  
*Inaperturopollenites* spp. .... 2.5%  
*Leiotriletes directus* .... 2.5%  
*Osmundacidites* sp. (indet.) .... 0.5%

*Polypodiisporites ipsviciensis* .... 2.5%  
*Punctatisporites walkomi* .... 0.5%  
*Semiretisporis antiquus* .... +  
*Stereisporites* sp. A .... +  
*Sulcosaccispora alaticonformis* .... +  
*Vitreisporites* sp. (indet.) .... 0.5%  
*Disaccites* spp. (indet.) .... 72.5%

## N.S. 272, 2201 ft., 6½ in. Count 200+

*Annulispora microannulata* .... +  
*Cadargasporites baculatus* .... +  
*Chordasporites australiensis* .... +  
*Circulisporites parvus* .... 0.5%  
*Craterisporites rotundus* .... 0.5%  
*Cycadopites nitidus* .... 5.5%  
*Dictyophyllidites mortoni* .... 0.5%  
*Duplexisporites problematicus* .... 5.5%  
*Guthoerlisporites cancellosus* .... +  
*Inaperturopollenites* sp. .... 1.0%  
*Leiotriletes directus* .... 4.5%  
*Lophotriletes* sp. .... 0.5%  
*Osmundacidites* sp. .... 0.5%  
*Platysaccus queenslandi* .... 1.0%  
*Polypodiisporites ipsviciensis* .... 1.0%  
*Stereisporites antiquasporites* .... 0.5%  
*Vitreisporites* sp. (indet.) .... 0.5%  
*Disaccites* spp. (indet.) .... 78.0%

## N.S. 272, 2138 ft., 5 in. Count 200+

*Annulispora microannulata* .... 0.5%  
*Apiculatisporis* spp. .... 3.5%  
*Araucariacites* sp. .... 0.5%  
*Camerosporites verrucosus* .... 0.5%  
*Converrucosisporites* cf. *cameroni* .... 0.5%  
*Craterisporites rotundus* .... 0.5%  
*Cycadopites crassimarginis* .... 1.5%  
*Cycadopites nitidus* .... 11.5%  
*Dictyophyllidites mortoni* .... 4.0%  
*Duplexisporites problematicus* .... 4.5%  
*Duplicisporites* sp. .... +  
*Granulatisporites* sp. .... 0.5%  
*Inaperturopollenites* sp. .... 0.5%  
*Leiotriletes directus* .... 17.0%  
*Lophotriletes* spp. .... 2.5%  
cf. *Kraeuselisporites* sp. .... 0.5%  
*Osmundacidites* sp. .... 0.5%  
*Polypodiisporites ipsviciensis* .... 41.5%  
*Stereisporites antiquasporites* .... 0.5%  
*Stereisporites* sp. (indet.) .... 1.0%  
*Disaccites* spp. (indet.) .... 8.0%

## N.S. 272, 2045 ft., 10 in. Count 200+

*Annulispora microannulata* .... 0.5%  
*Apiculatisporis* spp. .... 1.0%  
*Aratrisporites banksi* .... +  
*Araucariacites* sp. .... 1.0%  
*Calamospora tener* .... 2.0%  
*Camerosporites verrucosus* .... +  
*Chordasporites australiensis* .... +  
*Clavatriletes* cf. *hammenii* .... 0.5%  
*Converrucosisporites cameroni* .... 0.5%  
*Craterisporites rotundus* .... 0.5%  
*Cycadopites* sp. .... +  
*Cycadopites nitidus* .... 8.0%  
*Dictyophyllidites mortoni* .... 6.5%  
*Distalanulisporites* cf. *punctus* .... +  
*Duplexisporites problematicus* .... 6.0%  
*Guthoerlisporites cancellosus* .... +  
*Inaperturopollenites* spp. .... 1.5%  
*Leiotriletes directus* .... 14.5%  
*Lophotriletes* sp. .... 0.5%  
*Neoraistrickia taylorii* .... +  
*Osmundacidites* spp. .... 7.0%  
*Polycingulatisporites densatus* .... +  
*Polypodiisporites ipsviciensis* .... 6.5%  
*Stereisporites antiquasporites* .... +  
*Stereisporites* sp. (indet.) .... 0.5%  
*Tuberculatisporites aberdarensis* .... +  
*Verrucosisporites* sp. .... 0.5%  
*Disaccites* spp. (indet.) .... 43.0%  
Gen. nov. A .... +



| N.S. 272, 1952 ft., 9 in.                | Count 200+ |
|------------------------------------------|------------|
| <i>Annulispora microannulata</i>         | +          |
| <i>Apiculatisporis globosus</i>          | +          |
| <i>Apiculatisporis</i> sp. (indet.)      | 2.0%       |
| <i>Araucariacites</i> sp.                | 1.0%       |
| <i>Camerosporites verrucosus</i>         | 0.5%       |
| <i>Circulisporites parvus</i>            | 1.5%       |
| <i>Clavatriletes</i> cf. <i>hammenii</i> | 0.5%       |
| <i>Conaletes</i> sp.                     | 2.5%       |
| <i>Converrucosisporites cameroni</i>     | +          |
| <i>Craterisporites rotundus</i>          | +          |
| <i>Cycadopites nitidus</i>               | 3.0%       |
| <i>Dictyophyllidites mortoni</i>         | 1.0%       |
| <i>Duplexisporites problematicus</i>     | 14.5%      |
| <i>Foveosporites</i> sp.                 | 0.5%       |
| <i>Granulatisporites</i> spp.            | 1.5%       |
| <i>Guthoerlisporites cancellosus</i>     | 0.5%       |
| <i>Inaperturopollenites</i> sp.          | 0.5%       |
| <i>Leiotriletes directus</i>             | 2.0%       |
| <i>Lophotriletes</i> spp.                | 2.0%       |
| <i>Neoraistrickia taylorii</i>           | +          |
| <i>Osmundacidites</i> spp.               | 2.5%       |
| <i>Polypodiisporites ipsviciensis</i>    | 4.0%       |
| <i>Punctatosporites walkomi</i>          | 1.0%       |
| <i>Stereisporites antiquasporites</i>    | +          |
| <i>Stereisporites perforatus</i>         | +          |
| <i>Stereisporites</i> sp. A              | +          |
| <i>Stereisporites</i> sp. (indet.)       | 1.0%       |
| <i>Verrucosporites</i> sp.               | 0.5%       |
| <i>Vitreisporites</i> sp. (indet.)       | 0.5%       |
| <i>Disaccites</i> spp. (indet.)          | 57.0%      |
| Gen. nov. A                              | +          |

| N.S. 272, 1925 ft., 2 in.                 | Count 200+ |
|-------------------------------------------|------------|
| <i>Annulispora microannulata</i>          | +          |
| <i>Chordasporites australiensis</i>       | 1.0%       |
| <i>Converrucosisporites cameroni</i>      | +          |
| <i>Craterisporites rotundus</i>           | +          |
| <i>Cycadopites</i> sp.                    | +          |
| <i>Cycadopites nitidus</i>                | 3.0%       |
| <i>Dictyophyllidites mortoni</i>          | 0.5%       |
| <i>Duplexisporites problematicus</i>      | +          |
| <i>Duplicisporites</i> sp. A              | +          |
| <i>Inaperturopollenites</i> sp.           | 0.5%       |
| <i>Leiotriletes directus</i>              | 1.5%       |
| <i>Lophotriletes</i> cf. <i>bauhiniae</i> | +          |
| <i>Neoraistrickia</i> cf. <i>taylorii</i> | +          |
| <i>Platysaccus queenslandi</i>            | +          |
| <i>Polypodiisporites ipsviciensis</i>     | 4.0%       |
| <i>Semiretisporis antiquus</i>            | +          |
| <i>Verrucosisporites</i> sp.              | 0.5%       |
| <i>Vitreisporites pallidus</i>            | 0.5%       |
| <i>Vitreisporites</i> sp. (indet.)        | 1.0%       |
| <i>Disaccites</i> spp. (indet.)           | 87.5%      |

| N.S. 272, 1877 ft., 2 in.                    | Count 200+ |
|----------------------------------------------|------------|
| <i>Acanthotriletes</i> sp.                   | +          |
| <i>Apiculatisporis</i> sp.                   | 0.5%       |
| <i>Aratrisporites flexibilis</i>             | +          |
| <i>Araucariacites</i> sp.                    | 10.0%      |
| <i>Calamospora tener</i>                     | 0.5%       |
| <i>Conaletes</i> sp.                         | 0.5%       |
| <i>Converrucosisporites cameroni</i>         | +          |
| <i>Conuvucosisporites</i> sp.                | +          |
| <i>Cycadopites crassimarginis</i>            | +          |
| <i>Cycadopites nitidus</i>                   | 5.0%       |
| <i>Dictyophyllidites mortoni</i>             | 4.0%       |
| <i>Duplexisporites problematicus</i>         | 0.5%       |
| <i>Guthoerlisporites cancellosus</i>         | +          |
| <i>Inaperturopollenites</i> spp.             | 3.5%       |
| <i>Leiotriletes directus</i>                 | 8.5%       |
| <i>Lophotriletes</i> sp.                     | 0.5%       |
| <i>Neoraistrickia taylorii</i>               | +          |
| <i>Polypodiisporites ipsviciensis</i>        | 12.0%      |
| <i>Pustulatisporites blackstonensis</i>      | +          |
| <i>Stereisporites</i> sp.                    | 1.5%       |
| <i>Verrucosisporites</i> spp.                | 1.5%       |
| <i>Vitreisporites microsaccus</i>            | +          |
| <i>Vitreisporites</i> cf. <i>microsaccus</i> | 0.5%       |
| <i>Vitreisporites pallidus</i>               | 3.0%       |

|                                    |       |
|------------------------------------|-------|
| <i>Vitreisporites</i> sp. (indet.) | 1.0%  |
| <i>Disaccites</i> spp.             | 47.0% |
| Gen. nov. A                        | +     |

| N.S. 272, 1846 ft., 5 in.                        | Count 200+ |
|--------------------------------------------------|------------|
| <i>Acanthotriletes</i> sp.                       | 0.5%       |
| <i>Annulispora microannulata</i>                 | +          |
| <i>Clavatriletes</i> cf. <i>hammenii</i>         | +          |
| <i>Conaletes</i> sp.                             | 1.0%       |
| <i>Craterisporites rotundus</i>                  | +          |
| <i>Cycadopites</i> sp.                           | 0.5%       |
| <i>Cycadopites nitidus</i>                       | 3.5%       |
| <i>Dictyophyllidites mortoni</i>                 | 8.0%       |
| cf. <i>Discisporites</i> sp.                     | +          |
| <i>Duplexisporites problematicus</i>             | 8.5%       |
| <i>Foveosporites</i> sp.                         | 0.5%       |
| <i>Inaperturopollenites</i> sp.                  | 1.5%       |
| <i>Leiotriletes directus</i>                     | 8.5%       |
| <i>Lophotriletes</i> sp.                         | 0.5%       |
| <i>Lycopodiumsporites</i> sp.                    | +          |
| <i>Osmundacidites parvus</i>                     | 0.5%       |
| <i>Osmundacidites</i> sp. (indet.)               | 0.5%       |
| <i>Polypodiisporites</i> cf. <i>ipsviciensis</i> | 5.5%       |
| <i>Semiretisporis antiquus</i>                   | 0.5%       |
| <i>Stereisporites antiquasporites</i>            | +          |
| <i>Stereisporites</i> sp. A                      | +          |
| <i>Stereisporites</i> sp. (indet.)               | 4.0%       |
| <i>Sulcosaccispora alaticonformis</i>            | +          |
| <i>Vitreisporites microsaccus</i>                | 31.0%      |
| <i>Disaccites</i> spp. (indet.)                  | 75.5%      |

| N.S. 272, 1782 ft., 7½ in.            | Count 200+ |
|---------------------------------------|------------|
| <i>Acanthotriletes</i> sp.            | 1.0%       |
| <i>Annulispora microannulata</i>      | 0.5%       |
| <i>Apiculatisporis</i> sp.            | 0.5%       |
| cf. <i>Chordasporites</i> sp.         | 0.5%       |
| <i>Cycadopites nitidus</i>            | 2.5%       |
| <i>Dictyophyllidites mortoni</i>      | 0.5%       |
| <i>Duplexisporites problematicus</i>  | 1.0%       |
| <i>Guthoerlisporites cancellosus</i>  | 0.5%       |
| <i>Leiotriletes directus</i>          | 7.0%       |
| <i>Lophotriletes</i> spp.             | 1.5%       |
| <i>Platysaccus queenslandi</i>        | 0.5%       |
| <i>Polycingulatisporites</i> sp.      | 0.5%       |
| <i>Polypodiisporites ipsviciensis</i> | 7.0%       |
| <i>Stereisporites</i> sp.             | 0.5%       |
| <i>Vitreisporites pallidus</i>        | 0.5%       |
| <i>Disaccites</i> spp. (indet.)       | 75.5%      |

## ABERDARE CONGLOMERATE

| N.S. 272, 1634 ft., 10 in                    | Count 200+ |
|----------------------------------------------|------------|
| <i>Acanthotriletes</i> sp.                   | 0.5%       |
| cf. <i>Accinctisporites ligatus</i>          | +          |
| <i>Anapiculatisporites pristidentatus</i>    | +          |
| <i>Annulispora microannulata</i>             | 1.0%       |
| <i>Apiculatisporis</i> spp. (indet.)         | 3.0%       |
| <i>Araucariacites</i> sp.                    | 0.5%       |
| <i>Baculatisporites comaumensis</i>          | 0.5%       |
| <i>Baculatisporites</i> sp.                  | +          |
| cf. <i>Biretisporites</i> sp.                | 0.5%       |
| <i>Camerozonosporites rudis</i>              | 0.5%       |
| <i>Camerosporites verrucosus</i>             | 35.5%      |
| <i>Circulisporites parvus</i>                | 0.5%       |
| <i>Conaletes</i> sp.                         | 2.0%       |
| <i>Converrucosisporites</i> sp.              | 0.5%       |
| <i>Craterisporites rotundus</i>              | 0.5%       |
| <i>Cycadopites</i> cf. <i>crassimarginis</i> | 0.5%       |
| <i>Cycadopites nitidus</i>                   | 1.0%       |
| <i>Dictyophyllidites mortoni</i>             | 0.5%       |
| <i>Discisporites</i> sp.                     | 0.5%       |
| <i>Duplexisporites problematicus</i>         | 0.5%       |
| <i>Foveosporites</i> sp.                     | +          |
| <i>Gliscopollis meyeriana</i>                | +          |
| <i>Granulatisporites</i> sp. (indet.)        | 0.1%       |
| <i>Guthoerlisporites cancellosus</i>         | 0.5%       |
| <i>Inaperturopollenites</i> spp.             | 2.0%       |
| <i>Leiotriletes directus</i>                 | 6.0%       |
| <i>Lophotriletes</i> sp.                     | 0.5%       |
| <i>Neoraistrickia</i> sp.                    | +          |
| <i>Osmundacidites</i> spp.                   | 2.5%       |



|                                               |       |
|-----------------------------------------------|-------|
| <i>Pilasporites fuscus</i> .....              | +     |
| <i>Polycingulatisporites crenulatus</i> ..... | +     |
| <i>Polypodiisporites ipsviciensis</i> .....   | 12.0% |
| <i>Punctatisporites</i> spp. ....             | 1.0%  |
| <i>Pustulatisporites blackstonensis</i> ..... | 0.5%  |
| <i>Semiretisporis antiquus</i> .....          | 2.5%  |
| <i>Stereisporites antiquasporites</i> .....   | 0.5%  |
| <i>Stereisporites</i> sp. (indet.) .....      | 1.0%  |
| <i>Tuberculatosporites aberdarensis</i> ..... | 2.0%  |
| <i>Verrucosisporites</i> spp. ....            | 7.0%  |
| <i>Disaccites</i> spp. (indet.) .....         | 12.5% |

## RACEVIEW FORMATION

## N.S. 272, 1600 ft., 2 in. Count 200+

|                                                 |       |
|-------------------------------------------------|-------|
| <i>Acanthotriletes</i> sp. ....                 | +     |
| <i>Anapiculatisporites pristidentatus</i> ..... | +     |
| <i>Annulispota folliculosa</i> .....            | 0.5%  |
| <i>Annulispota microannulata</i> .....          | +     |
| <i>Apiculatisporis globosus</i> .....           | +     |
| <i>Camerosporites verrucosus</i> .....          | +     |
| <i>Conaletes</i> sp. ....                       | 21.0% |
| <i>Converrucosisporites cameroni</i> .....      | 0.5%  |
| <i>Converrucosisporites</i> sp. ....            | 1.0%  |
| <i>Craterisporites rotundus</i> .....           | +     |
| <i>Cycadopites</i> sp. ....                     | 0.5%  |
| <i>Dictyophyllidites mortoni</i> .....          | 1.0%  |
| cf. <i>Discisporites psilatus</i> .....         | +     |
| <i>Duplexisporites problematicus</i> .....      | 41.5% |
| <i>Foveosporites moretonensis</i> .....         | +     |
| <i>Foveosporites</i> sp. ....                   | +     |
| <i>Hamiapollenites insculptus</i> .....         | +     |
| <i>Inaperturopollenites</i> sp. ....            | 0.5%  |
| <i>Indusiisporites</i> sp. ....                 | 0.5%  |
| <i>Krauseisporites</i> sp. ....                 | 0.5%  |
| <i>Leiotriletes directus</i> .....              | 14.0% |
| <i>Neoraistrickia taylorii</i> .....            | +     |
| <i>Osmundacidites</i> spp. ....                 | 2.5%  |
| <i>Polycingulatisporites crenulatus</i> .....   | +     |
| <i>Polycingulatisporites densatus</i> .....     | 1.0%  |
| <i>Polycingulatisporites mooniensis</i> .....   | +     |
| <i>Polypodiisporites ipsviciensis</i> .....     | 6.5%  |
| <i>Semiretisporis antiquus</i> .....            | 1.0%  |
| <i>Stereisporites antiquasporites</i> .....     | 0.5%  |
| <i>Stereisporites</i> sp. ....                  | 0.5%  |
| <i>Sulcosaccispora alaticonformis</i> .....     | +     |
| cf. <i>Taurocusporites</i> sp. ....             | +     |
| <i>Disaccites</i> spp. (indet.) .....           | 6.5%  |

## N.S. 272, 1513 ft., 7 in. Count 200+

|                                                |       |
|------------------------------------------------|-------|
| <i>Acanthotriletes</i> sp. ....                | +     |
| <i>Apiculatisporis globosus</i> .....          | +     |
| <i>Apiculatisporis</i> spp. (indet.) .....     | 2.0%  |
| <i>Cadargasporites baculatus</i> .....         | 0.5%  |
| <i>Cadargasporites granulatus</i> .....        | +     |
| <i>Cadargasporites reticulatus</i> .....       | 1.0%  |
| <i>Camerosporites verrucosus</i> .....         | 1.0%  |
| <i>Clavatriletes</i> cf. <i>hammenii</i> ..... | 0.5%  |
| <i>Converrucosisporites cameroni</i> .....     | +     |
| <i>Cycadopites nitidus</i> .....               | 1.5%  |
| cf. <i>Densosporites</i> sp. ....              | +     |
| aff. <i>Densosporites</i> sp. ....             | 0.5%  |
| <i>Dictyophyllidites mortoni</i> .....         | 2.0%  |
| <i>Duplexisporites problematicus</i> .....     | 9.0%  |
| <i>Endosporites</i> sp. ....                   | 0.5%  |
| <i>Foveosporites moretonensis</i> .....        | +     |
| <i>Foveosporites</i> sp. ....                  | 1.0%  |
| aff. <i>Foveosporites</i> sp. ....             | 0.5%  |
| <i>Inaperturopollenites</i> sp. ....           | 0.5%  |
| <i>Leiotriletes directus</i> .....             | 6.5%  |
| <i>Lophotriletes</i> sp. ....                  | 0.5%  |
| <i>Lycopodiumsporites</i> sp. ....             | +     |
| <i>Osmundacidites</i> spp. ....                | 12.5% |
| <i>Platysaccus queenslandi</i> .....           | 1.5%  |
| <i>Platysaccus</i> sp. ....                    | 0.5%  |
| <i>Polycingulatisporites crenulatus</i> .....  | +     |
| <i>Polycingulatisporites densatus</i> .....    | 0.5%  |
| <i>Polycingulatisporites mooniensis</i> .....  | +     |
| <i>Polycingulatisporites</i> sp. ....          | +     |

|                                             |       |
|---------------------------------------------|-------|
| <i>Polypodiisporites ipsviciensis</i> ..... | 0.5%  |
| <i>Semiretisporis antiquus</i> .....        | 9.5%  |
| <i>Verrucosisporites</i> sp. ....           | 1.5%  |
| <i>Disaccites</i> spp. (indet.) .....       | 46.0% |

## N.S. 272, 1377 ft., 3 in. Count 200+

|                                               |       |
|-----------------------------------------------|-------|
| <i>Acanthotriletes</i> sp. ....               | 0.5%  |
| <i>Alisporites lowoodensis</i> .....          | +     |
| <i>Annulispota microannulata</i> .....        | +     |
| <i>Apiculatisporis</i> spp. ....              | 2.0%  |
| <i>Camerosporites verrucosus</i> .....        | 1.0%  |
| <i>Cycadopites nitidus</i> .....              | +     |
| <i>Dictyophyllidites mortoni</i> .....        | 2.5%  |
| <i>Discisporites psilatus</i> .....           | +     |
| <i>Duplexisporites problematicus</i> .....    | 2.0%  |
| <i>Duplicisporites</i> sp. A. ....            | 0.5%  |
| <i>Foveosporites moretonensis</i> .....       | 0.5%  |
| <i>Foveosporites</i> sp. ....                 | 1.0%  |
| aff. <i>Foveosporites</i> sp. ....            | +     |
| <i>Gliscopollis meyeriana</i> .....           | +     |
| <i>Granulatisporites</i> sp. ....             | 0.5%  |
| <i>Guthoerlisporites cancellosus</i> .....    | +     |
| <i>Inaperturopollenites</i> sp. ....          | 0.5%  |
| <i>Leiotriletes directus</i> .....            | 6.0%  |
| <i>Lophotriletes</i> spp. ....                | 1.0%  |
| <i>Lycopodiumsporites rosewoodensis</i> ..... | +     |
| <i>Osmundacidites wellmanii</i> .....         | 1.0%  |
| <i>Osmundacidites</i> sp. (indet.) .....      | 4.0%  |
| <i>Platysaccus queenslandi</i> .....          | 1.0%  |
| cf. <i>Podocarpidites</i> sp. ....            | 0.5%  |
| <i>Polycingulatisporites crenulatus</i> ..... | +     |
| cf. <i>Protohaploxypinus</i> sp. ....         | +     |
| <i>Semiretisporis antiquus</i> .....          | 3.5%  |
| <i>Stereisporis perforatus</i> .....          | 0.5%  |
| <i>Stereisporites</i> sp. (indet.) .....      | 0.5%  |
| <i>Verrucosisporites</i> spp. ....            | 1.0%  |
| <i>Vitreisporites pallidus</i> .....          | 0.5%  |
| <i>Disaccites</i> spp. (indet.) .....         | 69.5% |

## N.S. 272, 1332 ft., 10½ in. Count 200+

|                                               |       |
|-----------------------------------------------|-------|
| <i>Acanthotriletes</i> sp. ....               | 0.5%  |
| <i>Apiculatisporis</i> sp. ....               | 0.5%  |
| <i>Araucariacites</i> sp. ....                | 1.0%  |
| <i>Cadargasporites baculatus</i> .....        | 0.5%  |
| <i>Cadargasporites reticulatus</i> .....      | +     |
| <i>Cadargasporites</i> sp. ....               | +     |
| <i>Converrucosisporites cameroni</i> .....    | +     |
| <i>Cycadopites nitidus</i> .....              | 4.0%  |
| <i>Cycadopites</i> sp. ....                   | +     |
| <i>Dictyophyllidites mortoni</i> .....        | 1.5%  |
| <i>Granulatisporites</i> sp. ....             | 0.5%  |
| <i>Inaperturopollenites</i> spp. ....         | 2.0%  |
| <i>Indusiisporites</i> sp. ....               | 0.5%  |
| <i>Leiotriletes directus</i> .....            | 7.5%  |
| <i>Lophotriletes</i> spp. ....                | 2.0%  |
| <i>Osmundacidites</i> spp. ....               | 1.0%  |
| <i>Platysaccus queenslandi</i> .....          | 0.5%  |
| <i>Polycingulatisporites crenulatus</i> ..... | +     |
| <i>Polypodiisporites ipsviciensis</i> .....   | 13.0% |
| <i>Semiretisporis antiquus</i> .....          | 0.5%  |
| <i>Verrucosisporites</i> spp. ....            | 1.0%  |
| <i>Disaccites</i> spp. (indet.) .....         | 63.5% |

## N.S. 272, 1207 ft., 10 in. Count 200+

|                                                |      |
|------------------------------------------------|------|
| <i>Anapiculatisporites</i> sp. ....            | +    |
| <i>Annulispota microannulata</i> .....         | +    |
| cf. <i>Annulispota</i> sp. ....                | 0.5% |
| <i>Aratrisporites</i> sp. ....                 | 0.5% |
| <i>Araucariacites</i> sp. ....                 | 0.5% |
| <i>Baculatisporites comaumensis</i> .....      | 0.5% |
| <i>Cadargasporites baculatus</i> .....         | +    |
| <i>Camerosporites verrucosus</i> .....         | 1.5% |
| <i>Clavatriletes</i> cf. <i>hammenii</i> ..... | 7.0% |
| <i>Cycadopites nitidus</i> .....               | 2.0% |
| cf. <i>Densosporites</i> sp. ....              | 1.0% |
| <i>Dictyophyllidites mortoni</i> .....         | 2.0% |
| <i>Dictyophyllidites</i> sp. ....              | +    |
| <i>Duplexisporites problematicus</i> .....     | 0.5% |



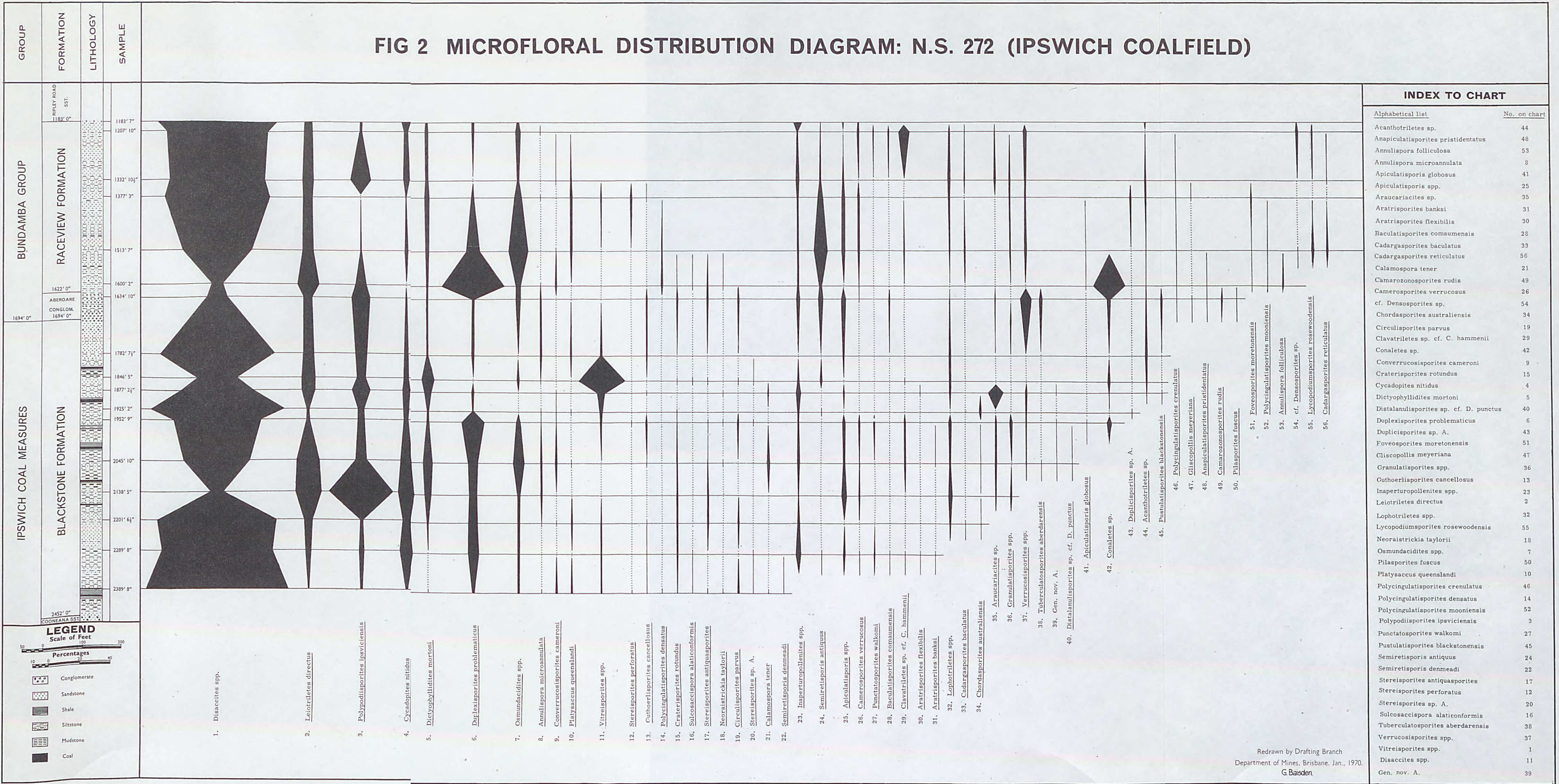
|                                            |       |
|--------------------------------------------|-------|
| <i>Foveosporites</i> sp. ....              | 1.0%  |
| <i>Granulatisporites</i> sp. ....          | 1.0%  |
| <i>Inaperturopollenites</i> sp. ....       | +     |
| <i>Indusiisporites</i> sp. ....            | 0.5%  |
| <i>Leiotriletes directus</i> ....          | 5.5%  |
| <i>Lophotriletes</i> sp. ....              | 0.5%  |
| <i>Lycopodiumsporites rosewoodensis</i>    | +     |
| <i>Osmundacidites</i> spp. ....            | 2.5%  |
| <i>Platysaccus</i> sp. ....                | 0.5%  |
| <i>Podocarpidites</i> sp. ....             | 0.5%  |
| <i>Polypodiisporites ipsviciensis</i> .... | 0.5%  |
| <i>Punctatosporites walkomi</i> ....       | 0.5%  |
| <i>Semiretisporis antiquus</i> ....        | 0.5%  |
| <i>Stereisporites</i> sp. ....             | 0.5%  |
| <i>Verrucosisporites</i> spp. ....         | 2.5%  |
| cf. <i>Voltziaceasporites</i> sp. ....     | 0.5%  |
| <i>Disaccites</i> spp. (indet.) ....       | 67.0% |

| N.S. 272, 1183 ft., 7 in.                  | Count 200+ |
|--------------------------------------------|------------|
| <i>Acanthotriletes</i> sp. ....            | 0.5%       |
| <i>Apiculatisporis</i> sp. ....            | 0.5%       |
| <i>Camerosporites verrucosus</i> ....      | 0.5%       |
| <i>Cycadopites nitidus</i> ....            | 6.5%       |
| <i>Cycadopites</i> sp. (indet.) ....       | 0.5%       |
| cf. <i>Densosporites</i> sp. ....          | +          |
| <i>Dictyophyllidites mortoni</i> ....      | 1.0%       |
| <i>Duplexisporites problematicus</i> ....  | 0.5%       |
| <i>Inaperturopollenites</i> spp. ....      | 5.5%       |
| <i>Leiotriletes directus</i> ....          | 4.5%       |
| <i>Osmundacidites</i> sp. ....             | 0.5%       |
| <i>Polypodiisporites ipsviciensis</i> .... | 0.5%       |
| <i>Semiretisporis antiquus</i> ....        | +          |
| <i>Stereisporites</i> sp. ....             | +          |
| ? <i>Striatissaccus</i> sp. ....           | 0.5%       |
| <i>Disaccites</i> spp. (indet.) ....       | 78.5%      |





FIG 2 MICROFLORAL DISTRIBUTION DIAGRAM: N.S. 272 (IPSWICH COALFIELD)













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